federal register

Thursday
October 29, 1998

Part II

Department of Labor

Mine Safety and Health Administration

30 CFR Part 57

Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners; Proposed Rule

DEPARTMENT OF LABOR

Mine Safety and Health Administration

30 CFR Part 57

RIN 1219–AB11

Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners

AGENCY: Mine Safety and Health Administration (MSHA), Labor.

ACTION: Proposed rule.

SUMMARY: This proposed rule would establish new health standards for underground metal and nonmetal mines that use equipment powered by diesel engines.

The proposed rule is designed to reduce the risks to underground metal and nonmetal miners of serious health hazards that are associated with exposure to high concentrations of diesel particulate matter (dpm). DPM is a very small particle in diesel exhaust. Underground miners are exposed to far higher concentrations of this fine particulate than any other group of workers. The best available evidence indicates that such high exposures put these miners at excess risk of a variety of adverse health effects, including lung cancer.

The proposed rule for underground metal and nonmetal mines would establish a concentration limit for dpm, and require mine operators to use engineering and work practice controls to reduce dpm to that limit. Underground metal and nonmetal mine operators would also be required to implement certain ''best practice'' work controls similar to those already required of underground coal mine operators under MSHA's 1996 diesel equipment rule. These operators would also be required to train miners about the hazards of dpm exposure.

MSHA has already proposed a rule to control dpm exposures in underground coal mines in a separate notice to the public published in the **Federal Register** on April 9, 1998 (62 FR 17492).

DATES: Comments must be received on or before February 26, 1999. Submit written comments on the information collection requirements by February 26, 1999.

ADDRESSES: Comments on the proposed rule may be transmitted by electronic mail, fax, or mail, or dropped off in person at any MSHA office. Comments by electronic mail must be clearly identified as such and sent to this e-mail address: comments@msha.gov. Comments by fax must be clearly identified as such and sent to: MSHA, Office of Standards, Regulations, and Variances, 703–235–5551. Send mail comments to: MSHA, Office of Standards, Regulations, and Variances, Room 631, 4015 Wilson Boulevard, Arlington, VA 22203–1984, or any MSHA district or field office. The Agency will have copies of the proposal available for review by the mining community at each district and field office location, at the National Mine Health and Safety Health Academy, and at each technical support center. The document will also be available for loan to interested members of the public on an as needed basis. MSHA will also accept written comments from the mining community at the field and district offices, at the National Mine Health and Safety Academy, and at technical support centers. These comments will become a part of the official rulemaking record. Interested persons are encouraged to supplement written comments with computer files or disks; please contact the Agency with any questions about format.

Written comments on the information collection requirements may be submitted directly to the Office of Information and Regulatory Affairs, New Executive Office Building, 725 17th Street, NW., Rm. 10235, Washington, D.C. 20503, Attn: Desk Officer for MSHA.

FOR FURTHER INFORMATION CONTACT: Carol J. Jones, Acting Director; Office of Standards, Regulations, and Variances; MSHA; (703)235–1910.

SUPPLEMENTARY INFORMATION:

I. Questions and Answers About This Proposed Rule

(A) General Information of Interest to the Entire Mining Community

(1) What Actions Are Being Proposed?

MSHA has determined that action is essential to reduce the exposure of miners to a harmful substance emitted from diesel engines—and that regulations are needed for this purpose in underground mines. This notice proposes requirements for underground metal and nonmetal mines.

The harmful substance is known as diesel particulate matter (dpm). As shown in Figure I–1, average concentrations of dpm observed in dieselized underground mines are up to 200 times as high as average environmental exposures in the most heavily polluted urban areas and up to 10 times as high as median exposures estimated for the most heavily exposed workers in other occupational groups. The best available evidence indicates that exposure to such high concentrations of dpm puts miners at significantly increased risk of incurring serious health problems, including lung cancer.

The goal of the proposed rule is to reduce underground miner exposures to attain the highest degree of safety and health protection that is feasible.

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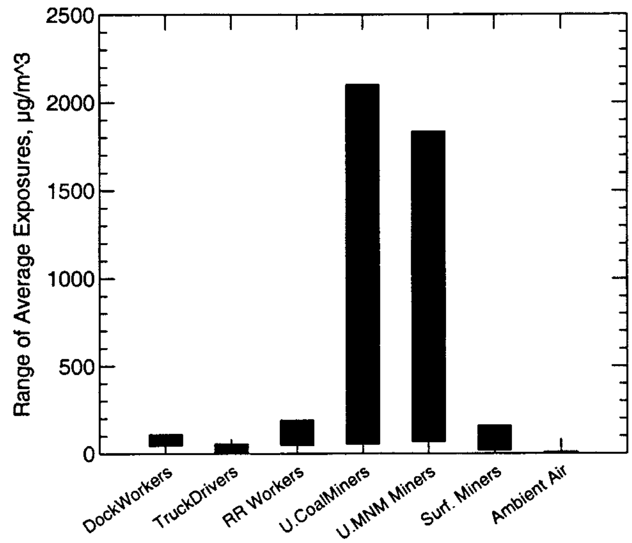
Figure I-1:
Comparative Exposures ($\mu g/m^3$)[1]



[1] Range of average dpm exposures observed at various mines for underground and surface miners compared to range of average exposures reported for other occupations and for urban ambient air. Averages are represented by median observed within mines for mine workers, by median as estimated with geometric mean reported for other occupations, and, for ambient air in urban environments, by the monthly mean estimated for different months and locations in Southern California. The range estimated for urban ambient air is roughly 1 to 10 $\mu g/m^3$. See part III for more detailed information.

Throughout this preamble, exposure information is presented in terms of "whole diesel particulate". Moreover, the information is presented in units of micrograms (μg) per cubic meter of air. However, in many of the references cited, exposure measurements may be expressed as milligrams (mg) per cubic meter of air.

1 mg/m^3 = 1 milligram per cubic meter of air
1 $\mu g/m^3$ = 1 microgram per cubic meter of air
1 milligram = 1000 micrograms.

To convert from milligrams to micrograms, multiply by 1000 -- or move the decimal point three places to the right. For example, 0.15 mg/m^3 = 150 $\mu g/m^3$.

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On April 9, 1998, (62 FR 17492), MSHA proposed a rule to achieve this goal in underground coal mines. MSHA's proposal would require the installation of high-efficiency filters on diesel-powered equipment to trap diesel particles before they enter the mine atmosphere. Following 18 months of education and technical assistance by MSHA after the rule is issued, filters would first have to be installed on permissible diesel-powered equipment. By the end of the following year (i.e., 30 months after the rule is issued), such filters would also have to be installed on any heavy-duty outby equipment. No specific concentration limit would be established in this sector; the proposed rule would require that filters be installed and properly maintained. Miner awareness training on the hazards of dpm would also be required.

With this notice, MSHA is proposing to adopt a different rule to achieve this goal in underground metal and nonmetal mines. MSHA is proposing that a limit on the concentration of dpm to which miners may be exposed would be established for underground metal and nonmetal mines. The limit would restrict dpm concentrations in underground metal and nonmetal mines to about 200 micrograms per cubic meter of air. Operators would be able to select whatever combination of engineering and work practice controls they want to keep the dpm concentration in the mine below this limit. The concentration limit would be implemented in two stages: an interim limit that would go into effect following 18 months of education and technical assistance by MSHA, and a final limit after 5 years. MSHA sampling would be used to determine compliance. The proposal for this sector would also require that all underground metal and nonmetal mines using diesel-powered equipment observe a set of ''best practices'' to reduce engine emissions—e.g., to use low-sulfur fuel. Similar practices are already in effect in underground coal mines as a result of MSHA's 1996 diesel equipment rule.

MSHA is not at this time proposing a rule applicable to surface mines. As illustrated in Figure I–1, in certain situations the concentrations of dpm at surface mines may exceed those to which rail, trucking and dock workers are exposed. Problem areas identified in this sector include production areas where miners work in the open air in close proximity to loader-haulers and trucks powered by older, out-of-tune diesel engines, or other confined spaces where diesel engines are running. The Agency believes, however, that these problems are currently limited and readily controlled through education and technical assistance. Using tailpipe exhaust extenders, or directing the exhaust across the engine fan, can dilute the high concentrations of dpm that might otherwise occur in areas immediately adjacent to mining equipment. Surface mine operators using or planning to switch to environmentally conditioned cabs to reduce noise exposure to equipment operators might also be able to incorporate filtration features that would protect these miners from high dpm concentrations as well. Completing already planned purchases of new trucks containing cleaner engines may also help reduce the isolated instances of high dpm concentrations at such mines.

The Agency would like to emphasize, however, that surface miners are entitled to the same level of protection as other miners, and that the Agency's risk assessment indicates that even short-term exposures to concentrations of dpm like those observed may result in serious health problems. Accordingly, in addition to providing education and technical assistance to surface mines, the Agency will also continue to evaluate the hazards of diesel particulate exposure at surface mines and will take any necessary action, including regulatory action if warranted, to help the mining community minimize any hazards.

(2) How Is This Notice of Proposed Rulemaking Organized? What Portions Do I Need To Read If I have Already Reviewed MSHA's Notice of Proposed Rulemaking To Limit dpm in Underground Coal Mines?

The proposed rule for underground metal and nonmetal mines can be found at the end of this Notice. The remainder of this preamble to the proposed rule (**SUPPLEMENTARY INFORMATION**) describes the Agency's rationale for what is being proposed.

Part I consists of a series of ''Questions and Answers.'' The Agency hopes they will provide most of the information you will need to formulate your comments. The first ten of these Questions and Answers (Section A) provide a general overview of this rulemaking. This is followed (Section B) by twenty additional Questions and Answers that address specific provisions of the proposed rule.

Part II provides some background information on nine topics that are relevant to this rulemaking. In order, the topics covered are: (1) The role of diesel-powered equipment in mining; (2) the composition of diesel exhaust and diesel particulate; (3) measurement of diesel particulate; (4) reducing soot at the source—EPA regulation of diesel engine design;(5) limiting the public's exposure to soot—EPA ambient air quality standards; (6) controlling diesel particulate emissions in mining—a toolbox; (7) existing mining standards that limit miner exposure to occupational diesel particulate emissions; (8) how other jurisdictions are restricting occupational exposure to diesel soot; and (9) MSHA's initiative to limit miner exposure to diesel particulate—the history of this rulemaking and related actions. Part II of this preamble is virtually identical to its counterpart in the preamble to MSHA's proposed rule to limit dpm concentrations in underground coal mines; the only exception is that the very last paragraph here, on the history of dpm rulemaking, has been updated to reflect the issuance of the proposed rule on underground coal. Appended to the end of this document, is an MSHA publication, ''Practical Ways to Reduce Exposure to Diesel Exhaust in Mining—A Toolbox,'' includes additional information on methods for controlling dpm, and a glossary of terms.

Part III is the Agency's risk assessment. The first section presents the Agency's data on current dpm exposure levels in each sector of the mining industry. The second section reviews the scientific evidence on the risks associated with exposure to dpm. The third section evaluates this evidence in light of the Mine Act's statutory criteria. Part III of this preamble is virtually identical to its counterpart in the preamble to MSHA's proposed rule to limit dpm concentrations in underground coal mines; the only exception is the language in Section III.3.c., reflecting the fact that the proposed rules are different for each sector, and hence had to be evaluated separately as to whether they satisfy the requirements of the law.

Part IV is a detailed section-by-section explanation and discussion of the elements of the proposed rule.

Part V is an analysis of whether the proposed rule meets the Agency's statutory obligation to attain the highest degree of safety or health protection for miners, with feasibility a consideration. This part begins with a review of the law and a profile of the industry's economic position. The next part explores the extent to which the proposed rule is expected to impact existing concentration levels, reviews significant alternatives that might provide more protection than the rule being proposed but which have not been adopted by the Agency due to feasibility concerns, and then discusses the feasibility of the rule being proposed. Part V draws upon a computer simulation of how the proposed rule in underground metal and nonmetal mines is expected to impact dpm concentrations; accordingly, an Appendix to this discussion provides information about the simulation methodology. The simulation method, which can be performed using a standard spreadsheet program, can be used to model conditions and control impacts in any underground mine; copies of this model are available to the mining community from MSHA.

Part VI reviews several impact analyses which the Agency is required to provide in connection with a proposed rulemaking. This information summarizes a more complete discussion that can be found in the Agency's Preliminary Regulatory Economic Analysis (PREA). Copies of this document are available from the Agency and will be posted on the MSHA Web site (http://www.msha.gov).

Part VII is a complete list of publications referenced by the Agency in the preamble.

(3) What Evidence Does MSHA Have That Current Underground Concentrations of DPM Need To Be Controlled?

The best available evidence MSHA has at this time is that miners subjected to an occupational lifetime of dpm exposure at concentrations we presently find in underground mines face a significant risk of material impairment to their health.

It has been recognized for some time that miners working in close contact with diesel emissions can suffer acute reactions—e.g., eye, nose and throat irritations—but questions have persisted as to what component of the emissions was causing these problems, whether exposure increased the risk of other adverse health effects, and the level of exposure creating health consequences.

In recent years, there has been growing evidence that it is the very small respirable particles in diesel exhaust (dpm) that trigger a variety of adverse health outcomes. These particles are generally less than one-millionth of a meter in diameter (submicron), and so can readily penetrate into the deepest recesses of the lung. They consist of a core of the element carbon, with up to 1,800 different organic compounds adsorbed onto the core, and some sulfates as well. (A diagram of dpm can be found in Part II of this preamble—see Figure II–3). The physiological mechanism by which dpm triggers particular health outcomes is not yet known. One or more of the organic substances adsorbed onto the surface of the core of the particles may be responsible for some health effects, since these include many known or suspected mutagens and carcinogens. But some or all of the health effects might also be triggered by the physical properties of these tiny particles, since some of the health effects are observed with high exposures to any ''fine particulate,'' whether the particle comes from diesel exhaust or another source.

There is clear evidence that exposure to high concentrations of dpm can result in a variety of serious health effects. These health effects include: (i) Sensory irritations and respiratory symptoms serious enough to distract or disable miners; (ii) death from cardiovascular, cardiopulmonary, or respiratory causes; and (iii) lung cancer.

By way of example of the non-cancer effects, there is evidence that workers exposed to diesel exhaust during a single shift suffer material impairment of lung capacity. A control group of unexposed workers showed no such impairment, and workers exposed to filtered diesel exhaust (i.e., exhaust from which much of the dpm has been removed) experienced, on average, only about half as much impairment. Moreover, there are a number of studies quantifying significant adverse health effects—as measured by lost work days, hospitalization and increased mortality rates—suffered by the general public when exposed to concentrations of fine particulate matter like dpm far lower than concentrations to which some miners are exposed. The evidence from these fine particulate studies was the basis for recent rulemaking by the Environmental Protection Agency to further restrict the exposure of the general public to fine particulates, and the evidence was given very widespread and close scrutiny before that action was made final. Of particular interest to the mining community is that these fine particulate studies indicate that those who have pre-existing pulmonary problems are particularly at risk. Many individual miners in fact have such pulmonary problems, and the mining population as a whole is known to have such conditions at a higher rate than the general public.

Although no epidemiological study is flawless, numerous epidemiological studies have shown that long term exposure to diesel exhaust in a variety of occupational circumstances is associated with an increased risk of lung cancer. With only rare exceptions, involving relatively few workers and/or observation periods too short to reliably detect excess cancer risk, the human studies have consistently shown a greater risk of lung cancer among workers exposed to dpm than among comparable unexposed workers. When results from the human studies are combined, the risk is estimated to be 30–40 percent greater among exposed workers, if all other factors (such as smoking habits) are held constant. The consistency of the human study results, supported by experimental data establishing the plausibility of a causal connection, provides strong evidence that chronic dpm exposure at high levels significantly increases the risk of lung cancer in humans.

Moreover, all of the human occupational studies indicating an increased frequency of lung cancer among workers exposed to dpm involved average exposure levels estimated to be far below the levels observed in underground mines—and even below the limits being proposed. As noted in Part III, MSHA views extrapolations from animal experiments as subordinate to results obtained from human studies. However, it is noteworthy that dpm exposure levels recorded in some underground mines have been within the exposure range that produced tumors in rats.

Based on the scientific data available in 1988, the National Institute for Occupational Safety and Health (NIOSH) identified dpm as a probable or potential human carcinogen and recommended that it be controlled. Other organizations have made similar recommendations.

MSHA carefully evaluated all the evidence available in light of the requirements of the Mine Act. Based on this evaluation, MSHA has reached several conclusions:

(1) The best available evidence is that the health effects associated with exposure to dpm can materially impair miner health or functional capacity.

(2) At levels of exposure currently observed in underground mining, many miners are presently at significant risk of incurring these material impairments over a working lifetime.

(3) The reduction in dpm exposures that is expected to result from implementation of the proposed rule for underground metal and nonmetal mines would substantially reduce the significant risks currently faced by underground metal and nonmetal miners exposed to dpm.

MSHA had its risk assessment independently peer reviewed. The risk assessment presented here incorporates revisions made in accordance with the reviewers' recommendations. The reviewers stated that:

> * * * principles for identifying evidence and characterizing risk are thoughtfully set

out. The scope of the document is carefully described, addressing potential concerns about the scope of coverage. Reference citations are adequate and up to date. The document is written in a balanced fashion, addressing uncertainties and asking for additional information and comments as appropriate. (Samet and Burke, Nov. 1997.)

The proposed rule would reduce the concentration of one type of fine particulate in underground metal and nonmetal mines—that from diesel emissions—but would not explicitly control miner exposure to other fine airborne particulates present underground. In light of the evidence presented in the Agency's risk assessment on the risks that fine particulates in general may pose to the mining population, MSHA would welcome comments as to whether the Agency should also consider restricting the exposure of underground metal and nonmetal miners to all fine particulates, regardless of the source.

(4) Aren't NIOSH and the NCI Working on a Study That Will Provide Critical Information? Why Proceed Before the Evidence Is Complete?

NIOSH and the National Cancer Institute (NCI) are collaborating on a cancer mortality study that will provide additional information about the relationship between dpm exposure levels and disease outcomes, and about which components of dpm may be responsible for the observed health effects. The study is projected to take about seven years. The protocol for the study was recently finalized.

The information the study is expected to generate will be a valuable addition to the scientific evidence on this topic. But given its conclusions about currently available evidence, MSHA believes the Agency needs to take action now to protect miners' health. Moreover, as noted by the Supreme Court in an important case on risk involving the Occupational Safety and Health Administration, the need to evaluate risk does not mean an agency is placed into a ''mathematical straightjacket.'' *Industrial Union Department, AFL–CIO* v. *American Petroleum Institute,* 448 U.S. 607, 100 S.Ct. 2844 (1980). The Court noted that when regulating on the edge of scientific knowledge, absolute scientific certainty may not be possible, and ''so long as they are supported by a body of reputable scientific thought, the Agency is free to use conservative assumptions in interpreting the data * * * risking error on the side of overprotection rather than underprotection.'' (*Id.* at 656.) This advice has special significance for the mining community, because a singular historical factor behind the enactment of the current Mine Act was the slowness in coming to grips with the harmful effects of other respirable dust (coal dust).

It is worth noting that while the cohort selected for the NIOSH/NCI study consists of underground miners (specifically, underground metal and nonmetal miners), this choice is in no way linked to MSHA's regulatory framework or to miners in particular. This cohort was selected for the study because it provides the best population for scientists to study. For example, one part of the study would compare the health experiences of miners who have worked underground in mines with long histories of diesel use with the health experiences of similar miners who work in surface areas where exposure is significantly lower. Since the general health of these two groups is very similar, this will help researchers to quantify the impacts of diesel exposure. No other population is as easy to study for this purpose. But as with any such epidemiological study, the insights gained are not limited to the specific population used in the study. Rather, the study will provide information about the relationship between exposure and health effects that will be useful in assessing the risks to any group of workers in a dieselized industry.

(5) What Are the Impacts of the Proposed Rule?

Costs. Table I–1 provides cost information. Some explanation is necessary.

Costs consist of two components: ''initial'' costs (e.g., capital costs for equipment, or the one-time costs of developing a procedure), which are then amortized over a period of years in accordance with a standardized formula to provide an ''annualized'' cost; and ''annual'' costs that occur every year (e.g., maintenance or training costs). Adding together the ''annualized'' initial costs and the ''annual'' costs provides the per year costs for the rule.

It should be noted that in amortizing the initial costs, a net present value factor was applied to certain costs: those associated with provisions where mine operators do not have to make capital expenditures until some period of time after the effective date. Detailed information on this point is contained in the Agency's Preliminary Regulatory Economic Analysis (PREA), as are the Agency's cost assumptions.

The costs per year to the underground metal and nonmetal industry are about $19.2 million. These costs are higher than the costs for the proposed rule for underground coal mines, reflecting the much more intense use of diesel-powered equipment in this sector. The Agency spent considerable time developing its cost assumptions and estimates, which are spelled out in detail in the Agency's PREA. Assumptions are based upon information provided by MSHA technical personnel, who have had discussions with manufacturers of engines and mining equipment, and from journals and reports published by independent organizations that collect data about the mining industry. The Agency would encourage the mining community to provide detailed comments in this regard so as to ensure these cost assumptions and estimates are as accurate as possible. With respect to the largest cost item—the cost to meet the proposed concentration limit in underground metal and nonmetal mines—MSHA assumed that engineering controls, such as low emission engines, ceramic filters, oxidation catalytic converters, and cabs would be needed on diesel powered equipment. Most of the engineering controls would be needed on diesel equipment used for production, while a small amount of diesel equipment that is used for support purposes would need engineering controls. In addition to these controls, MSHA assumed that some underground metal and nonmetal mines would need to make ventilation changes in order to meet the proposed concentration limits.

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Table I–1.—Compliance Cost for Underground Metal and Nonmetal Mine Operators

(Dollars X 1,000)

	Large Mines (≥20)			Small Mines (<20)			Total Mines		
Detail	(A) Total [Col.B+C]	(B) Annual-ized	(C) Annual	(D) Total [Col.E+F]	(E) Annual-ized	(F) Annual	(G) Total [Col.H+I]	(H) Annual-ized	**(I) Annual**
57.5060(a)	$8,369	$8,369	$0	$2,677	$2,677	$0	$11,046	$11,046	$0
57.5060(b)	$4,910	$4,910	$0	$1,627	$1,627	$0	$6,537	$6,537	$0
57.5060(c)	$10	$10	$0	$2	$2	$0	$12	$12	$0
57.5062	$5	$0	$5	$1	$0	$1	$6	$0	$6
57.5066	$30	$25	$5	$8	$6	$2	$38	$31	$7
57.5067	$731	$731	$0	$121	$121	$0	$852	$852	$0
57.5070	$198	$0	$198	$5	$0	$5	$203	$0	$203
57.5071	$364	$25	$339	$122	$0	$122	$486	$25	$461
57.5075	$3	$0	$3	$1	$0	$1	$4	$0	$4
Total	$14,620	$14,070	$550	$4,564	$4,433	$131	$19,184	$18,503	$681

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As required by the Regulatory Flexibility Act, MSHA has performed a review of the effects of the proposed rule on ''small entities''. The results—including information about the average cost for mines in each sector with less than 500 employees and mines in each sector with less than 20 miners—are summarized in response to Question 7.

Paperwork. Tables I–2 and I–3 show additional paperwork burden hours which the proposed rule would require. Only those existing or proposed regulatory requirements which would, as a result of this rulemaking, result in new burden hours, are noted. The costs for these paperwork burdens, a subset of the overall costs of the proposed rule, are specifically noted in Part VII of the Agency's PREA. Table I–2 shows the burden hours for large and small mines—those with less than 20 miners.

TABLE I–2.—UNDERGROUND METAL AND NONMETAL MINE BURDEN HOURS

Detail	Large	Small	Total
57.5060	306	123	429
57.5062	49	11	60
57.5066	207	76	283
57.5070	136	6	142
57.5071	2,600	213	2,813
57.5075	131	7	138
Total	3,429	436	3,865

Table I–3 shows the additional burden hours for diesel engine manufacturers. The compliance costs related to diesel equipment manufacturers are assumed to be passed through to underground metal and nonmetal operators as explained in the PREA. Thus, diesel equipment manufacturers are not estimated to incur any direct cost as a result of this rule.

TABLE I–3.—DIESEL ENGINE MANUFACTURERS BURDEN HOURS

Detail	Total
Part 7, Subpart E	36
Total	36

Benefits. The proposed rule would reduce the exposure of underground metal and nonmetal miners to dpm, thereby reducing the risk of adverse health effects and their concomitant effects.

The risks being addressed by this rulemaking arise because some miners are exposed to high concentrations of the very small particles produced by engines that burn diesel fuel. As discussed in Part II of the preamble, diesel powered engines are used increasingly in underground mining operations because they permit the use of mobile equipment and provide a full range of power for both heavy-duty and light-duty operations (i.e., for production equipment and support equipment, respectively), while avoiding the explosive hazards associated with gasoline. But underground mines are confined spaces which, despite ventilation requirements, tend to accumulate significant concentrations of particles and gases—both those produced by the mine itself (e.g., methane gas and silica dust liberated by mining operations) and those produced by equipment used in the mine.

As discussed in MSHA's risk assessment (Part III of this preamble), the concentrations of diesel particulates to which some underground miners are currently exposed are significantly higher than the concentrations reported for other occupations involving the use of dieselized equipment; and at such concentrations, exposure to dpm by underground miners over a working lifetime is associated with an excess risk of a variety of adverse health effects.

The nature of the adverse health effects associated with such exposures suggests the nature of the savings to be derived from controlling exposure. Acute reactions can result in lost production time for the operator and lost pay (and perhaps medical expenses) for the worker. Hospital care for acute breathing crises or cancer treatment can be expensive, result in lost income for the worker, lost income for family members who need to provide care and lost productivity for their employers, and may well involve government payments (e.g., Social Security disability and Medicare). Serious illness and death lead to long term income losses for the families involved, with the potential for costs from both employers (e.g., workers' compensation payouts, pension payouts) and society as a whole (e.g., government assisted aid programs).

The information available to the Agency suggests that as exposure is reduced, so are the adverse health consequences. For example, data collected on the effects of environmental exposure to fine particulates suggest that reducing occupational dpm exposures by as little as 75 $\mu g/m^3$ (roughly corresponding to a reduction of 25 $\mu g/m^3$ in 24-hour ambient atmospheric concentration) could lead to significant reductions in the risk of various acute responses, including mortality. And chronic occupational exposure has been linked to an estimated 30 to 40 percent increase in the risk of lung cancer. All the quantitative risk models reviewed by NIOSH suggest excess risks of lung cancer of more than one per thousand for miners who have long-term occupational exposures to dpm concentrations in excess of 1000 $\mu g/m^3$, and the epidemiologically-based risk estimates suggest higher risks. The Agency's estimate is that implementation of the proposed rule would avoid 28 lung cancers per 1,000 affected miners, or approximately 7 lung cancer cases a year over an initial 65-year period.[2] Note that because lung cancer associated with diesel particulate matter typically arises from cumulative exposure and after some latency period, these health benefits-in terms of the reduced incidence of lung cancer illness and subsequent death-will not materialize until some years after passage of the proposed rule.

The yearly reduction in excess lung cancer deaths due to reduced exposure to diesel particulate matter may occur gradually, depending on the historical cumulative exposure to diesel particulate matter among the veteran workforce. Since the average latency period for lung cancer is 20 years, the full benefit associated with a concentration limit of 200 $\mu g/m^3$ may not be seen before then.

Despite these quantitative indications, quantification of the benefits is difficult. Although increased risk of lung cancer has been shown to be associated with dpm exposure among exposed workers, a conclusive dose-response relationship upon which to base quantification of benefits has not been demonstrated. The Agency nevertheless intends, to the extent it can, to develop an appropriate analysis quantifying benefits in connection with the final rule.

The Agency does not have much experience in quantifying benefits in the case of a proposed health standard (other than its recent proposal on controlling mining noise, where years of compliance data and hearing loss studies provide a much more complete quantitative picture than with dpm). MSHA therefore welcomes suggestions for the appropriate approach to use to quantify the benefits likely to be derived from this rulemaking. Please identify scientific studies, models, and/or assumptions suitable for estimating risk at different exposure levels, and data on numbers of miners exposed to different levels of dpm.

[2] In the long run, the average approaches 464÷45=10 lung cancers avoided per year as the number of years considered increases beyond 65.

(6) Did MSHA Actively Consider Alternatives to What Is Being Proposed?

Yes. Once MSHA determined that the evidence of risk required a regulatory action, the Agency considered a number of alternative approaches, the most significant of which are reviewed in Part V of the preamble.

The consideration of options proceeded in accordance with the requirements of Section 101(a)(6)(A) of the Federal Mine Safety and Health Act of 1977 (the ''Mine Act''). In promulgating standards addressing toxic materials or harmful physical agents, the Secretary must promulgate standards which most adequately assure, on the basis of the best available evidence, that no miner will suffer material impairment of health over his/her working lifetime. In addition, the Mine Act requires that the Secretary, when promulgating mandatory standards pertaining to toxic materials or harmful physical agents, consider other factors, such as the latest scientific data in the field, the feasibility of the standard and experience gained under the Mine Act and other health and safety laws. Thus, the Mine Act requires that the Secretary, in promulgating a standard, attain the highest degree of health and safety protection for the miner, based on the ''best available evidence,'' with feasibility a consideration.

As a result, MSHA seriously considered a number of alternatives that would, if adopted as part of the proposed rule, have provided increased protection—and would also have significantly increased costs. For example, the Agency considered proposing a more stringent concentration limit for dpm in underground metal and nonmetal mines, or shortening the time frame to achieve compliance with that limit. But as discussed in more detail in Part V, MSHA concluded, however, that such an approach may not be feasible for the underground sector at this time. Options considered by the Agency included: requiring the installation of a particulate filter on every new piece of diesel-powered equipment added to the fleet of an underground metal or nonmetal mine regardless of the dpm concentration level, as an added layer of miner protection; establishing a fixed schedule for operator monitoring of the concentration of diesel particulate emissions; and requiring control plans be preapproved by MSHA before implementation to ensure their effectiveness had been verified. These approaches were not included in the proposal because MSHA concluded that less stringent alternatives could achieve the same level of protection with less adverse impact.

MSHA also considered alternatives that would have led to a significantly lower-cost proposal, e.g., establishing a less stringent concentration limit in underground metal and nonmetal mines, or increasing the time for mine operators to come into compliance. However, based on the current record, MSHA has tentatively concluded that such approaches would not be as protective as those being proposed, and that the approach proposed is both economically and technologically feasible. As a result, the Agency has not proposed to adopt these alternatives.

MSHA also explored whether to permit the use of administrative controls (e.g., rotation of personnel) and personal protective equipment (e.g., respirators) to reduce the diesel particulate exposure of miners. It is generally accepted industrial hygiene practice, however, to eliminate or minimize hazards at the source before resorting to personal protective equipment. Moreover, such a practice is generally not considered acceptable in the case of carcinogens since it merely places more workers at risk. Accordingly, the proposal explicitly prohibits the use of such approaches, except in those limited cases where MSHA approves, due to technological constraints, a 2-year extension for an underground metal and nonmetal mine on the time to comply with the final concentration limit.

MSHA did make a concerted effort to design the requirements of the proposal to minimize unnecessary burdens. Each element of the proposal was independently reviewed to ascertain whether it was really needed, as were all the paperwork requirements, and each was designed with cost-effectiveness in mind. Training and operator sampling requirements, for example, were specifically designed to be performance-oriented to minimize costs, while at the same time crafted to ensure that each operator's activities provide necessary protections.

The Agency considered requiring the underground metal and nonmetal sector to use work practice and engine controls exactly like those already applicable in the underground coal sector as a result of MSHA's diesel equipment rule (62 FR 55412). Such an alternative would have required each metal and nonmetal operator: (a) to conduct weekly emissions tests of diesel-powered equipment in underground metal and nonmetal mines instead of just tagging suspect equipment for prompt inspection; (b) to establish training programs for maintenance personnel; and (c) to turn over the mine's diesel fleet within a few years so as to have only approved engines. The agency concluded, however, that the conditions which warrant such an approach in underground coal mines had not been established for metal and nonmetal mines; and that with respect to the risks created by dpm, the approach taken in the proposed rule could provide adequate protection in a cost-effective manner.

The agency hopes that comments and suggestions from the mining community on the proposed rule will help it identify further improvements in this regard.

(7) What Will the Impact Be on the Smallest Underground Metal and Nonmetal Mines? What Consideration Did MSHA Give to Alternatives for the Smallest Mines?

The Regulatory Flexibility Act requires MSHA and other regulatory agencies to conduct a review of the effects of proposed rules on small entities. That review is summarized here; a copy of the full review is included in Part VI of this preamble, and in the Agency's PREA. The Agency encourages the mining community to provide comments on this analysis.

The Small Business Administration generally considers a small mining entity to be one with less than 500 employees. MSHA has traditionally defined a small mine to be one with less than 20 miners, and has focused special attention on the problems experienced by such mines in implementing safety and health rules, e.g., the Small Mine Summit, held in 1996. Accordingly, MSHA has separately analyzed the impact of the proposed rule on mines with 500 employees or less, and those with less than 20 miners.

Table I–4 summarizes MSHA's estimates of the average costs of the proposed rule to a small underground metal and nonmetal mine.

TABLE I–4.—AVERAGE COST PER SMALL UNDERGROUND METAL AND NONMETAL MINE

Size	UG M/NM <500	UG M/NM <20
Cost per mine ...	$87,800	$56,100

Pursuant to the Regulatory Flexibility Act, MSHA must determine whether the costs of the proposed rule constitute a ''significant impact on a substantial number of small entities.'' Pursuant to the Regulatory Flexibility Act, if an Agency determines that a proposed rule does not have such an impact, it must publish a ''certification'' to that effect. In such a case, no additional analysis is required (5 U.S.C. § 605).

In evaluating whether certification is appropriate, MSHA utilized an impact analysis comparing the costs of the proposal to the revenues of the sector involved (only the revenues for underground metal and nonmetal mines are used in this calculation).

The Agency has, as required by law (5 U.S.C. § 603), developed an initial regulatory flexibility analysis which is set forth in Part VI of this preamble (and the Agency's PREA). In addition to a succinct statement of the objects of the proposed rule and other information required by the Regulatory Flexibility Act, the analysis reviews alternatives considered by the Agency with an eye toward the nature of small business entities. MSHA welcomes comment on this analysis, on possible impacts of the proposed rule on small mines, and suggestions to ameliorate those impacts.

In promulgating standards, MSHA does not reduce protection for miners employed at small mines. But MSHA does consider the impact of its standards on even the smallest mines when it evaluates the feasibility of various alternatives. For example, a major reason why MSHA concluded it needed to stagger the effective dates of some of the requirements in the proposed rule is to ensure that it would be feasible for the smallest mines to have adequate time to come into compliance.

Consistent with recent amendments to the Regulatory Flexibility Act under SBREFA (the Small Business Regulatory Enforcement Fairness Act), MSHA has already started considering actions it can take to minimize the anticipated compliance burdens of this proposed rule on smaller mines. For example, no limit on dpm concentration would be in effect in underground metal and nonmetal mines for 18 months—and during that time, the Agency plans to provide extensive compliance assistance to the mining community. The metal and nonmetal community would also have an additional three and a half years to comply with the final concentration limit, which in many cases means these mines may have a full five years of technical assistance before any engineering controls are required. MSHA would focus its efforts on smaller operators in particular—to training them in measuring dpm concentrations, and providing technical assistance on available controls. The Agency will also issue a compliance guide, and continue its current efforts to disseminate educational materials and software. Comment is invited on whether compliance workshops or other such approaches would be valuable.

(8) Why Would the Proposed Rule Require Special Training for Underground Miners Exposed to Diesel Exhaust? And Why Does the Proposed Rule not Address Medical Surveillance and Medical Removal Protection for Affected Miners?

Training. Diesel particulate exposure has been linked to a number of serious health hazards, and the Agency's risk assessment indicates that the risks should be reduced as much as feasible. It has been the experience of the mining community that miners must be active and committed partners along with government and industry in successfully reducing these risks. Therefore, training miners as to workplace risks is a key component of mine safety and health programs. This rulemaking continues that approach.

Specifically, pursuant to proposed § 57.5070(a), any underground miner ''who can reasonably be expected to be exposed to diesel emissions'' would have to receive instruction in: (1) The health risks associated with dpm exposure; (2) in the methods used in the mine to control diesel particulate concentrations; (3) in identification of the personnel responsible for maintaining those controls; and (4) in actions miners must take to ensure the controls operate as intended. The training is to be provided annually in all mines using diesel-powered equipment, and is to be provided without charge to the miner.

MSHA does not expect this training to be a significant new burden for mine operators. The training required can be provided at minimal cost and with minimal disruption. The proposal would not require any special qualifications for instructors, nor would it specify the minimum hours of instruction. The purpose of the proposed requirement is miner awareness, and MSHA believes this can be accomplished by operators in a variety of ways. In mines that have regular safety meetings before the shift begins, devoting one of those meetings to the topic of diesel particulate would probably be a very easy way to convey the necessary information. Mines not having such a regular meeting can schedule a ''toolbox'' talk for this purpose. MSHA will be developing an outline of educational material that can be used in these settings. Simply providing miners with a copy of MSHA's toolbox, and reviewing how to use it, can cover several of the training requirements.

Operators may choose to include required dpm training under Part 48 training as an additional topic. Part 48 training plans, however, must be approved. There is no existing requirement that Part 48 training include a discussion of the hazards and control of diesel emissions. While mine operators are free to cover additional topics during the Part 48 training sessions, the topics that must be covered during the required time frame may make it impracticable to cover other matters within the prescribed time limits. Where the time is available in mines using diesel-powered equipment, operators should be free to include the dpm instruction in their proposed Part 48 training plans. The Agency does not believe special language in the proposed rule is needed to permit this action under Part 48, but welcomes comment in this regard.

The proposal would not require the mine operator to separately certify the completion of the diesel particulate training, but some evidence that the training took place would have to be produced upon request. A serial log with the employee's signature is a perfectly acceptable practice in this regard.

Medical surveillance. Another important source of information that miners and operators can use to protect health can come from medical surveillance programs. Such programs provide for medical evaluations or tests of miners exposed to particularly hazardous substances, at the operator's expense, so that a miner exhibiting symptoms or adverse test results can receive timely medical attention, ensure that personal exposure is reduced as appropriate and controls are reevaluated. Sometimes, to ensure that this source of information is effective, medical removal (transfer) protection must also be required. Medical transfer may address protection of a miner's employment, a miner's pay retention, a miner's compensation, and a miner's right to opt for medical removal.

As a general rule, medical surveillance programs have been considered appropriate when the exposures are to potential carcinogens. MSHA has in fact been considering a generic requirement for medical surveillance as part of its air quality standards rulemaking. MSHA also recently proposed a medical surveillance program for hearing, as part of the Agency's proposed rule on noise exposure (61 FR 66348).

MSHA is not proposing such a program for dpm at this time because it is still gathering information on this issue. The Agency, however, welcomes comments regarding this issue and also, on medical removal.

Specifically, the Agency would welcome comment on the following questions: (a) What kinds of examinations or tests would be appropriate to detect whether miners are suffering ill effects as a result of dpm exposure; (b) the qualifications of those who would have to perform such examinations or tests and their availability; (c) whether such examinations or tests need to be provided and how frequently once the provisions of the rule are in effect; and (d) whether medical removal protections should be a component of a medical surveillance program.

(9) What Are the Major Issues on Which MSHA Wants Comments? What If I Already Submitted Comments on the Same Point on the Proposed Rule for the Underground Coal Sector?

MSHA wants the benefit of your experience and expertise: whether as a miner or mine operator in any mining sector; a manufacturer of diesel-powered engines, equipment, or emission control devices; or as a scientist, doctor, engineer, or safety and health professional. MSHA intends to review and consider all comments submitted to the Agency.

While MSHA will endeavor to consider relevant comments on the proposed rule for underground coal mines in evaluating what to do in the underground metal and nonmetal sector (e.g., comments on risk, the effectiveness of filtration devices, etc.), the record established for each rulemaking is separate. Accordingly, the Agency encourages those who are interested in both rulemakings to submit separate or duplicate comments for each.

The following list identifies some topics on which the Agency would particularly like information; requests for information on other topics can be found throughout the preamble.

(a) *Assessment of Risk/Benefits of the Rule.* Part III of this preamble reviews information that the Agency has been able to obtain to date on the risks of dpm exposure to miners. The Agency welcomes your comments on the significance of the material already in the record, and any information that can supplement the record. For example, additional information on existing and projected exposures to dpm and to other fine particulates in various mining environments would be useful in getting a more complete picture of the situation in various parts of the mining industry. Additional information on the health risks associated with exposure to dpm—especially observations by trained observers or studies of acute or chronic effects of exposure to known levels of dpm or fine particles in general, information about pre-existing health conditions in individual miners or miners as a group that might affect their reactions to exposures to dpm or other fine particles, and information about how dpm affects human health—would help provide a more complete picture of the relationship between current exposures and the risk of health outcomes. Information on the costs to miners, their families and their employers of the various health problems linked to dpm exposure, and the prevalence thereof, would help provide a more complete picture of the benefits to be expected from reducing exposure. And as discussed in response to Question and Answer 5, the Agency would welcome advice about the assumptions and approach to use in quantifying the benefits to be derived from this rule.

(b) *Proposed rule.* Part IV of this preamble reviews each provision of the proposed rule, Part V discusses the economic and technological feasibility of the proposed rule, and Part VI reviews the projected impacts of the proposed rule. MSHA would welcome comments on each of these topics.

The Agency would like your thoughts on the specific alternative approaches discussed in Part V. The options discussed include: adjusting the concentration limit for dpm; adjusting the phase-in time for the concentration limit; and requiring that specific technology be used in lieu of establishing a concentration limit.

The Agency would also like your thoughts on more specific changes to the proposed rule that should be considered. For example, for underground metal and nonmetal mines, MSHA is proposing to measure the amount of total carbon to measure dpm concentrations. MSHA welcomes information relevant to this proposal. The Agency is also interested in obtaining as many examples as possible as to the specific situation in individual mines: the composition of the diesel fleet, what controls cannot be utilized due to special conditions, and any studies of alternative controls using the computer spreadsheet described in the Appendix to Part V of this preamble. (See Adequacy of Protection and the Feasibility of the Proposed Rule). Information about the availability and costs of various control technologies that are being developed (e.g., high-efficiency ceramic filters), experience with the use of available controls, and information that will help the Agency evaluate alternative approaches for underground metal and nonmetal mines would be most welcome. Comments from the underground coal sector on the implementation to date of diesel work practices (like the rule limiting idling, and the training of those who provide maintenance) would be helpful in evaluating related proposals for the underground metal and nonmetal sector. The Agency would appreciate information about any unusual situations that might warrant the application of special provisions.

(c) *Compliance Guidance.* The Agency welcomes comments on any topics on which initial guidance ought to be provided as well as any alternative practices which MSHA should accept for compliance before various provisions of the rule go into effect.

(d) *Minimizing Adverse Impact of the Proposed Rule.* The Agency has set forth its assumptions about impacts (e.g., costs, paperwork, and impact on smaller mines in particular) in some detail in this preamble and in the PREA, and would welcome comments on the methodology. Information on current operator equipment replacement planning cycles, tax, State requirements, or other information that might be relevant to purchasing new engines or control technology would likewise be helpful. The Agency would also welcome comments on the financial situation of the underground metal and nonmetal sector, including information that may be relevant to only certain commodities.

(10) When Will the Rule Become Effective? Will MSHA Provide Adequate Guidance Before Implementing the Rule?

Some requirements of the proposed rule would go into effect 60 days after the date of promulgation: the requirement to provide basic hazard training to miners who are exposed underground to dpm, the ‘‘best practice’’ requirements (e.g., the requirement to use only low-sulfur fuel), and some related recordkeeping requirements.

The next requirements would go into effect 18 months after the date the rule is promulgated. Underground metal and nonmetal mines would have to comply with an interim dpm concentration limit.

Finally, five years after the date the rule is promulgated, all underground metal and nonmetal mines would have to comply with a final dpm concentration limit.

MSHA intends to provide considerable technical assistance and guidance to the mining community before the various requirements go into effect, and be sure MSHA personnel are fully trained in the requirements of the rule. A number of actions have already been taken toward this end. The Agency held workshops on this topic in 1995 which provided the mining community an opportunity to share advice on how to control dpm concentrations. The Agency has published a ''toolbox'' of methods available to mining operators to achieve reductions in dpm concentration (appended to the end of this document is a copy of an MSHA publication, ''Practical Ways to Reduce Exposure to Diesel Exhaust in Mining—A Toolbox,'' which includes additional information on methods for controlling dpm, and a glossary of terms). In addition, MSHA has developed a computer spreadsheet template which allows an operator to model the application of alternative engineering controls to reduce dpm. The design of the model, and several specific mine profiles developed illustrating its use, are discussed in part V of the preamble.

The Agency is committed to issuing a compliance guide for mine operators providing additional advice on implementing the rule. MSHA would welcome suggestions on matters that should be discussed in such a guide. MSHA would also welcome comments on other actions it could take to facilitate implementation, and in particular whether a series of additional workshops would be useful.

(B) Additional Information About the Proposed Rule for Underground Metal and Nonmetal Mines

(11) What Basic Changes Does the Proposal Make to Part 57, the Health Rules for Underground Metal and Nonmetal Mines?

What follows is a general overview of the changes proposed to Part 57. The remainder of this part is devoted to addressing the details of the proposed rule in this sector.

The first thing the proposal would do is require underground metal and nonmetal mines to observe a set of ''best practices'' to reduce engine emissions of dpm underground. Only low-sulfur diesel fuel and EPA-approved fuel additives would be permitted to be used in diesel-powered equipment in underground areas. Idling of such equipment that is not required for normal mining operations would be prohibited. In addition, diesel engines would have to be maintained in good order to ensure that deterioration does not lead to emissions increases—approved engines would have to be maintained in approved condition; the emission related components of non-approved engines would have to be maintained in accordance with manufacturer specifications; and any installed emission device would have to be maintained in effective operating condition. Equipment operators in underground metal and nonmetal mines would be authorized to tag equipment with potential emissions-related problems, and tagged equipment would have to be ''promptly'' referred for a maintenance check. As an additional safeguard in this regard, maintenance to ensure compliance with these requirements would have to be done by persons qualified by virtue of training or experience to perform the maintenance.

The proposed rule would also require that, with the exception of diesel engines used in ambulances and fire-fighting equipment, any diesel engines added to the fleet of an underground metal or nonmetal mine after the rule's promulgation must be an engine approved by MSHA under Part 7 or Part 36. The composition of the existing fleet would not be impacted by this part of the proposed rule.

While these proposed work practice controls are similar to existing rule in effect in underground coal mines, they are somewhat less stringent. For example, unlike in coal mines, the proposed maintenance rule in underground metal and nonmetal mines would not require operators to establish training programs that meet certain criteria. Nor would the proposed rule require weekly tailpipe emissions tests.

The second thing the proposal would do is establish a limit on the concentration of dpm permitted in areas of an underground metal or nonmetal mine where miners work or travel.

The proposed standard is intended to limit dpm concentrations to which miners are exposed to about 200 micrograms per cubic meter of air—expressed as 200_{DPM} µg/m^3. However, in an effort to make things easier on a day-to-day basis for the mining community, the proposed concentration limit on dpm for this sector would be expressed in terms of the measurement method MSHA will use for compliance purposes to determine dpm concentrations. (That method, NIOSH Analytical Method 5040, is specified in proposed § 57.5061, and is discussed in more detail in response to Question 12. MSHA is proposing to use it because of its accuracy). The method will analyze a dust sample to determine the amount of total carbon present. Total carbon comprises 80–85% of the dpm emitted by diesel engines. Accordingly, using the lower boundary of 80%, a concentration limit of 200_{DPM} µg/m^3 can be achieved by restricting total carbon to 160_{TC} µg/m^3. This is the way the proposed standard is expressed:

> After [insert the date 5 years after the date of promulgation of this rule] any mine operator covered by this part shall limit the concentration of diesel particulate matter to which miners are exposed by restricting the average eight-hour equivalent full shift airborne concentration of total carbon, where miners normally work or travel, to 160 micrograms per cubic meter of air (160_{TC} µg/m^3).

All underground metal and nonmetal mines would be given a full five years to meet this limit, which is referred to in this preamble as the ''final'' concentration limit. However, starting eighteen months after the rule is promulgated, underground metal and nonmetal mines would have to observe an ''interim'' dpm concentration limit—expressed as a restriction on the concentration of total carbon of 400 micrograms per cubic meter (400_{TC} µg/m^3). The interim limit would bring the concentration of whole dpm in underground metal and nonmetal mines to which miners are exposed down to about 500 micrograms per cubic meter. No limit at all on the concentration of dpm would be applicable for the first eighteen months following promulgation. Instead, this period would be used to provide compliance assistance to the metal and nonmetal mining community to ensure it understands how to measure and control diesel particulate matter concentrations in individual operations (and to implement work practice controls).

A mine operator would have to use engineering or work practice controls to keep dpm concentrations below the applicable limit. Administrative controls (e.g., the rotation of miners) and personal protective equipment (e.g., respirators) are explicitly barred as a means of compliance with the interim or final concentration limit. An operator could filter the emissions from diesel-powered equipment, install cleaner-burning engines, increase ventilation, improve fleet management, or use a variety of other readily available controls; the selection of controls would be left to the operator's discretion. MSHA has published a ''toolbox'' of approaches that can be used to reduce dpm; a copy of this useful publication is appended to the end of this document. The Agency has also developed a model that can be run on a standard spreadsheet program to compare the effects of alternative controls before purchase and implementation decisions are made. The model, and some examples of its use, are presented in Part V of this preamble.

The proposal would provide that, if an operator of a metal or nonmetal mine can demonstrate that there is no combination of controls that can, due to technological constraints, be implemented within the 5 years permitted to reduce the concentration of dpm to the final concentration limit, MSHA may approve an application for an additional extension of time to comply with the dpm concentration limit. Such a special extension is available only once, and is limited to 2 years. To obtain a special extension, an operator must provide information in the application adequate for MSHA to ensure that the operator will: (a) maintain concentrations at the lowest limit which is technologically achievable; and (b) take appropriate actions to minimize miner exposure (e.g., provide suitable respiratory protection during the extension period).

Measurements to determine noncompliance with the dpm concentration limit would be made directly by MSHA, rather than having the Agency rely upon operator samples. Under the rule, a single Agency sample, using the sampling and analytical method prescribed by the rule, would be adequate to establish a violation. MSHA would take measurement uncertainty into account before issuing a citation, as discussed in response to Question 12.

The proposed rule would require that if an underground metal or nonmetal mine exceeds the applicable limit on the concentration of dpm, a diesel particulate matter compliance plan must be established and remain in effect for 3 years. The purpose of such plans is to ensure that the mine has instituted practices that will demonstrably control dpm levels thereafter. Reflecting current practices in this sector, the plan would not have to be preapproved by MSHA. The plan would include information about the diesel-powered equipment in the mine and applicable controls. The proposed rule would require operator sampling to verify that the plan is effective in bringing dpm levels down below the applicable limit, with the records kept at the mine site with the plan to facilitate review. Failure of an operator to comply with the requirements of the dpm control plan or to conduct adequate verification sampling would be a violation; MSHA would not be required to sample to establish such a violation.

To enhance miner awareness of the hazards involved, mines using diesel-powered equipment must annually train miners exposed to dpm in the hazards associated with that exposure, and in the controls being used by the operator to limit dpm concentrations. An operator may propose to include this training in the Part 48 training plan.

The proposed rule would also require all operators in this sector using diesel-powered equipment to sample as often as necessary to effectively evaluate dpm concentrations at the mine. The purpose of this requirement is to assure that operators are familiar with current dpm concentrations so as to be able to protect miners. Since mine conditions vary, MSHA is not proposing to establish a defined schedule for operator sampling; but rather, to propose a performance-oriented approach. The Agency would evaluate compliance with this sampling obligation by reviewing evidence of operator compliance with the concentration limit, as well as information retained by operators about their sampling.

Consistent with the statute, the proposed rule would require that miners and their representatives have the right to observe any operator monitoring—including any sampling required to verify the effectiveness of a dpm control plan.

(12) How Is MSHA Proposing To Measure the Amount of dpm in Underground Metal and Nonmetal Mines?

Techniques for measuring dpm concentrations are reviewed in detail in Part II of this preamble.

For a method to be used for compliance purposes, it must be able to distinguish dpm from other particles present in various mines, be accurate at the concentrations to be measured, and consistently measure dpm regardless of the mix or condition of the equipment in the mine.

The technique being proposed for compliance sampling in underground metal and nonmetal mines meets these requirements. It involves sampling with a quartz fiber filter mounted in an open face filter holder, and a chemical analysis of the filter to determine the amount of carbon collected. The entire process, NIOSH Analytical Method 5040, has been validated as meeting NIOSH's accuracy criterion—i.e., that measurements come within 25% of the true concentration at least 95% of the time. While there are other methods that can be used to provide accurate measurements of diesel particulate matter in some types of mines and under some circumstances, this technique appears to provide consistent and accurate results in all underground metal and nonmetal mining environments.

Although the NIOSH method was validated using a regular respirable dust sampler, MSHA gave consideration to the use of a size selector impactor sampler, developed by the Bureau of Mines, that would not collect any dust over 1 micrometer (micron) in diameter. Canada is exploring the use of such an approach with an alternative analytical method. However, measurements by the Agency to date indicate that in some underground metal and nonmetal mines, as much as 30% of the dpm present may be larger than 1 micron in size. The Agency is continuing to evaluate such an approach, and welcomes comments on the implications to miners and mine operators of excluding from consideration this larger fraction of dpm.

The method described in NIOSH Analytical Method 5040 provides a way to determine the amount of diesel particulate in the sample. Diesel particulate consists of a core of elemental carbon onto which are adsorbed various organic components and sulfates. The NIOSH Analytical Method separately analyzes the amount of elemental carbon and the amount of organic carbon present in the sample. These two amounts are then added together to get the amount of total carbon present in the sample. In the absence of any measurable quantity of any other organic carbon source, this method provides a way of reliably measuring dpm at concentrations at and below the proposed final concentration limit.

MSHA has also evaluated other analytical approaches—the gravimetric method (simply weighing the sample), the respirable combustible dust (RCD) analysis used in Canada, and the elemental carbon approach. As discussed in detail in Part II, use of these methods to measure dpm for compliance purposes in underground metal and nonmetal mines present various questions that the Agency has not been able to satisfactorily address at point in the rulemaking process. For example, the gravimetric method has not been validated for use at lower concentration levels, the RCD method is not recommended for use in certain types of underground metal and nonmetal mines, and there appears to be some variability in the relationship between elemental carbon and whole diesel particulate.

MSHA does not believe that either oil mists or cigarette smoke in underground metal or nonmetal mines will pose a problem in using this method. MSHA currently has no data as to the frequency of occurrence or the magnitude of any potential interference from oil mist, but during its studies of measurement methods in underground mines, MSHA has not encountered situations where oil mist was found to be an interferant. Moreover, the Agency assumes that when operators implement the proposal's maintenance requirements, this will minimize any remaining potential for such interference. Cigarette smoking can be prohibited by an operator during any testing. MSHA welcomes comments as to the scope of any possible interferences with the proposed methods and measures for addressing them.

Proposed § 57.5061(a) would explicitly provide that MSHA use the validated NIOSH procedure for total carbon, or ''any method subsequently determined by NIOSH to provide equal or improved accuracy'' in underground metal and nonmetal mines. Measurement technology is always improving, and MSHA believes that providing for some flexibility in this regard can ultimately benefit the entire mining community.

Proposed § 57.5061(b) provides that a single sample using the prescribed method would provide an adequate basis for citing noncompliance. As with the sampling methodology, MSHA is proposing to specifically state this policy as a provision of the rule itself to ensure it is clearly understood. Single shift sampling is the normal practice for OSHA and MSHA. As is its practice with other compliance determinations based on measurement, MSHA would not issue a citation unless the measurement exceeds the compliance limit by a ''margin of error'' sufficient to demonstrate noncompliance at a 95% confidence level. While MSHA is still conducting research to determine exactly what margin of error would be appropriate to establish such a confidence level, the Agency expects it to be between 10 and 20% of the concentration limit. Thus, assuming for the sake of example that the margin of error is 15%, a citation would not be issued for exceeding the final concentration limit unless the measured total carbon is above 184_{TC} $\mu g/m^3$ (115% of 160_{TC} $\mu g/m^3$).

Finally, it should be noted that the proposed limit is expressed in terms of the average airborne concentration during each full shift expressed as an 8-hour equivalent. Measuring during the full shift ensures that the entire exposure is monitored, and the limit is based on the average exposure. Using an 8-hour equivalent ensures that a miner who works extended shifts would not have a higher exposure burden than a miner who works an 8-hour shift.

(13) Would the Concentration Limit Apply in All Areas of an Underground Metal or Nonmetal Mine?

The concentration limit would apply only in underground areas where miners normally work or travel. The purpose of this restriction is to ensure that mine operators do not have to monitor particulate concentrations in areas where miners do not normally work or travel—e.g., abandoned areas of a mine.

However, it should be noted that the proposed interim and final concentration limits would apply in any area of a mine where miners ''normally'' work or travel—not just where miners might be present at the moment.

(14) Does the Rule Contemplate That MSHA Use Area Sampling To Determine Compliance?

The limit on the concentration of diesel particulate to which miners are exposed is intended to be applicable to persons, occupations or areas. This means that the Agency may sample by attaching a sampler to an individual miner, locate the sampler on a piece of equipment where a miner may work, or locate the sampler at a fixed site where miners normally work or travel.

(15) What Is the Basis for the Concentration Limit Being Proposed in Underground Metal and Nonmetal Mines?

The proposed rule would seek to reduce exposures to dpm in underground areas of underground metal and nonmetal mines to a level of around 200_{DPM} $\mu g/m^3$. (As explained in response to Question 12, the concentration limit is being expressed in terms of the total carbon measurement system MSHA will use to determine the amount of dpm, 160_{TC} $\mu g/m^3$).

Look again at Figure I–1, which compares the range of exposures of different groups of workers. You can see that capping dpm concentrations at 200_{DPM} $\mu g/m^3$ (all the information on the figure is presented in terms of estimated whole diesel particulate) will eliminate the worst mining exposures. In fact, such a cap will bring miner exposures down to a level commensurate with those reported for other groups of workers who use diesel-powered equipment. The proposed rule would not bring concentrations down as far as the proposed ACGIH TLV[R] of 150_{DPM} $\mu g/m^3$. Nor does MSHA's risk assessment suggest that the proposed rule would eliminate the significant risks to miners of dpm exposure.

As a result of the Agency's statutory obligation to attain the highest degree of safety and health protection for miners, the Agency explored the option, and implications, of requiring mines in this sector to comply with a lower concentration limit than that being proposed. The Agency looked at simulations of the controls some underground metal and nonmetal mines might use to lower dpm concentrations, including at least one control with a major cost component (aftertreatment filter or new engine). The results, discussed in Part V of this preamble, indicate that although the matter is not free from question, it may not be feasible at this time for the underground metal and nonmetal mining industry as a whole to comply with a significantly lower limit than that being proposed. More information on this issue, and comments of the information presented by the Agency in Part V, would be appreciated.

The other side of this question—whether the rule that is proposed is feasible for the underground metal and nonmetal mining industry—is discussed in the next Question and Answer.

(16) Is It Feasible for the Metal and Nonmetal Industry as a Whole To Comply with the Proposed Concentration Limit?

MSHA has evaluated the feasibility of the concentration limit in the underground metal and nonmetal sector. Approximately 78 percent, of the 261 underground metal and nonmetal mines use diesel powered equipment, and MSHA estimates this sector has approximately 4,100 diesel engines. The engines can be of large size, and so tend to have high emissions. Moreover, unlike in the coal sector, there is no single control device that can be readily and widely applied to reduce dpm emissions in underground metal and nonmetal mines. The paper filter aftertreatment devices that can eliminate up to 95% of particulate matter emissions from permissible coal equipment are not available here without the addition of other controls. Permissible equipment requires the exhaust to be cooled to avoid explosive hazards; in turn, this permits paper afterfilters to be installed directly without burning. For most metal and nonmetal equipment, it is necessary to first install water scrubbers or other devices to cool the exhaust before using the paper filters. There are other types of filtering devices that could be directly applied to this equipment, but none to date that is quite as effective (although MSHA is seeking information as to whether creation of a market for filters could lead to prompt commercial development of ceramic filters with high particulate removal efficiencies). Moreover, the ventilation systems common in this sector, and the variation of mine types, suggested that a careful feasibility review is warranted.

Accordingly, MSHA undertook special analyses in which the Agency's staff experts simulated how various control methods could be used to meet the needs of some mines expected to have unusually difficult problems: an underground limestone mine, an underground (and underwater) salt mine, and an underground gold mine. The results of these analyses are discussed in Part V of the preamble, together with the methodology used in modeling the results. In each case, the analysis revealed that there are available controls that can bring dpm concentrations down to well below the final limit—even when the controls that needed to be purchased were not as extensive as those which the Agency is assuming will be needed in determining the costs of the proposed rule. As a result of these studies, the Agency has tentatively concluded that, in combination with the required ''best practices'', there are engineering and work practice controls available to bring dpm concentrations in all underground metal and nonmetal mines down to 400_{TC} $\mu g/m^3$ within 18 months. Moreover, based on the mines it has examined to date, MSHA has tentatively concluded that controls are available to bring dpm concentrations in all underground metal and nonmetal mines down to 160_{TC} $\mu g/m^3$ within 5 years.

The Agency would welcome comments from the mining community on the methodology of the model used in these studies, and hopes the mining community will submit the actual results of its own studies using the model. More information on the model is contained in Part V of the preamble. It uses a spreadsheet template that can be run on standard programs, and MSHA would be pleased to make copies available and answer any questions about the use of the model.

The best actions for an individual operator to take to come into compliance with the interim and final concentration limits will depend upon an analysis of the unique conditions at the mine. The proposed rule provides 18 months after it is promulgated for MSHA to provide technical assistance to individual mine operators. It also gives all mine operators in this sector an additional three and a half years to bring dpm concentrations down to the proposed final concentration limit—using an interim concentration limit during this time which the Agency is confident every mine in this sector can timely meet. And the rule provides an opportunity for a special extension for an additional two years for mines that have unique technological problems meeting the final concentration limit.

As noted during 1995 workshops co-sponsored by MSHA on methods for controlling diesel particulate, many underground metal and nonmetal mine operators have already successfully determined how to reduce diesel particulate concentrations in their mines. MSHA has disseminated the ideas discussed at these workshops to the entire mining community in a publication, ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox'' (a copy of this publication is appended to the end of this document). The control methods are divided into eight categories: use of low emission engines; use of low sulfur fuel; use of aftertreatment devices; use of ventilation; use of enclosed cabs; diesel engine maintenance; work practices and training; fleet management; and respiratory protective equipment. And as noted above, MSHA has designed a model in the form of a computer spreadsheet that can be used to simulate the effects of various controls on dpm concentrations. This model is discussed in Part V of the preamble, and several examples are provided. This makes it possible for individual underground mine operators to evaluate the impact on diesel particulate levels of various combinations of control methods, prior to making any investments, so each can select the most feasible approach for his or her mine.

(17) Suppose an Underground Metal or Nonmetal Mine Really Does Have a Unique Technological Problem That Precludes Timely Compliance? Will MSHA Utilize Qualified and Experienced Technical Personnel To Review Operator Applications for Special Extensions of Time To Comply With the Final Concentration Limit in Underground Metal and Nonmetal Mines?

It is MSHA's intent that primary responsibility for analysis of the operator's application for a special extension will rest with MSHA's district managers. District managers are the most familiar with the conditions of mines in their districts, and have the best opportunity to consult with miners as well. At the same time, MSHA recognizes that district managers may need assistance with respect to the latest technologies and solutions being used in similar mines elsewhere in the country. Accordingly, the Agency intends to establish within its Technical Support directorate in Arlington, Va., a special panel to consult on these issues, to provide assistance to district managers, and to give final approval of any application for a special extension.

(18) If a Special Extension of Time To Comply With the Final dpm Concentration Limit Is Approved for an Underground Metal or Nonmetal Mine, What Operating Parameters Would Be Imposed on That Mine during the Duration of the Special Extension?

Any parameters will be negotiated between the individual operator and MSHA.

An operator will begin the process by filing an application for a special extension. The application must set forth what actions the operator commits to taking to maintain the lowest concentration of diesel particulate achievable. The application must also include adequate information for the Secretary to ascertain the lowest concentration of diesel particulate achievable, as demonstrated by data collected under conditions that are representative of mine conditions using the total carbon sampling method. In addition, the application must set forth what actions the operator will take to minimize the exposure of miners who will have to work or travel in areas which are going to be above the concentration limit by virtue of the extension. Since administrative controls and personal protective equipment can help reduce miner exposure, under these special circumstances operators may propose to include use of these approaches in their applications.

In some cases, what may be involved is a small area with only limited miner access; in other cases, an entire working section may be involved. Rather than establish ''one-size-fits-all'' standards for such situations, the proposal leaves it to the operator to submit a suggested approach.

The proposed rule requires a mine operator to comply with the terms of an approved extension application, and a copy would be posted at the mine site. Failure to comply with the specific commitments agreed to as part of the extension, and contained therein, would thus be citable.

(19) Why Do Underground Metal and Nonmetal Mine Operators Have To Have a Diesel Particulate Control Plan?

Underground metal and nonmetal operators will not have to have a compliance plan if they are in compliance. Considerable time is provided under the proposed rule to come into compliance, and operators can thereafter monitor their mines to ensure they stay below the required concentration limit.

But some operators may decline to take the actions necessary to achieve compliance in a timely manner, and others may need to rethink their approaches from time to time as equipment changes increase dpm concentration levels. Providing for a control plan in the event of a violation of the concentration limit ensures that there is a deliberative effort as to how to solve the dpm concentration problem, and that everybody understands what is going to be done to eliminate it. Accordingly, proposed § 57.5062 requires that in the event an operator is determined to have exceeded the applicable limit on diesel particulate concentration, the operator must establish a diesel particulate control plan if one is not already in effect, or modify the existing diesel particulate control plan.

(20) Must dpm Control Plans in Metal and Nonmetal Mines Be Pre-Approved by MSHA? How Long Would They Last?

Operator control plans would NOT have to be approved by MSHA. This is consistent with the practice in this sector concerning ventilation plans (with which the dpm control plan may be combined). The Agency gave serious consideration to requiring approval of such plans to ensure there was agreement as to their effectiveness, or at least to approval of compliance plans for repeat violators; but in light of the resource demands this might impose on the agency, and the operator verification sampling built into the proposed rule, the Agency decided not to make such a proposal. Comment on this point is welcome.

A control plan for a metal or nonmetal mine would not need to be retained and modified forever—as is the practice with plans for underground coal mines. Rather, under the proposal, a dpm control plan in a metal or nonmetal mine would stay in effect for 3 years, and during its lifetime, the plan is to be modified as appropriate to reflect changes in mining conditions.

MSHA seriously considered requiring a longer lifetime for compliance plans. First, the Agency wants to provide a strong incentive to come into compliance in a timely fashion. Second, the Agency wants to be sure that where a plan is needed to clarify compliance obligations, it stay in place at a mine long enough to ensure that the obligations undertaken in the plan become a mine routine; the goal is to maintain a mine in compliance, not just have a temporary fix. The Agency also has to be realistic about conserving the resources of its health professionals; re-sampling mines whose control plans have expired takes resources away from other priorities. The Agency is aware, however, that operating under long-term control plans is not standard practice in metal and nonmetal mines. Moreover, it recognizes the need to re-sample all mines with some regularity due to changing mining conditions. Accordingly, the proposed rule seeks to strike a balance in this regard.

(21) What Must Be Included in a dpm Control Plan If One Is Required? And How Would Its Effectiveness Be Verified?

The diesel particulate control plan would include three elements: the controls the operator will utilize to maintain the concentration of diesel particulate at the mine to the applicable limit; a list of diesel-powered units maintained by the mine operator; and information about any unit's emission control device and the parameters of any other method used to control dpm concentrations. Upon request, the plan (or amended plan) is to be submitted to the District Manager, with a copy to the authorized representative of miners—but no approval process would be required; a copy is to be maintained at the mine site. Documentation verifying the effectiveness of the plan in controlling diesel particulate to the required level would have to be maintained with the plan, and submitted to MSHA upon request.

Proposed § 57.5062(c) provides that to verify the effectiveness of a control plan or amended control plan, operators must have monitoring data, collected using the total carbon method which MSHA will be required to use for enforcement purposes, sufficient to confirm that the plan or amended plan will control the concentration of diesel particulate to the applicable limit under conditions that can be reasonably anticipated in the mine.

Verification by operators is being proposed to ensure that primary responsibility for ensuring a dpm control plan is effective is not shifted to MSHA. The Agency has only limited resources to conduct sampling. Moreover, while a single sample can demonstrate that a mine is out of compliance under the conditions sampled, it takes multiple samples to demonstrate that miners are protected under the variety of conditions that can be reasonably anticipated in the mine (e.g., during production and seasonal changes). By clarifying operator responsibilities in this regard, the proposal ensures an appropriate balance of responsibilities.

The proposed rule does not specify that any defined number of samples must be taken—the intent is that the sampling provide a representative picture of whether the plan or amended plan is working. The proposed rule does, however, specify that the total carbon method be used for verification sampling. This is an exception to the general rule that mine operators have discretion in the choice of what sampling technique to use in their own monitoring programs (see response to Question 29). The purpose of verification sampling is to verify the effectiveness of a plan established or modified in response to a violation through MSHA sampling; if operators used an alternative technique to sample, it would complicate the determination of whether the violation was being adequately addressed by the plan.

(22) Why Is the Agency Proposing That All Underground Metal and Nonmetal Mines Follow Certain ''Best Practices''—Regardless of the Concentration of Diesel Particulates at Such Mines?

The Agency's risk assessment supports reduction of dpm to the lowest level possible. But as discussed in response to Question 16, feasibility considerations dictated proposing a concentration limit that does not eliminate the significant risks that dpm exposure poses to miners.

One approach that can be used to bridge the gap between risk and feasibility is to establish an ''action level''. In the case of MSHA's noise proposal, for example, MSHA proposed a ''permissible exposure level'' of a time-weighted 8-hour average (TWA_8) of 90 dBA (decibels, A-weighted), and an ''action level'' of half that amount—a TWA_8 of 85 dBA. In that case, MSHA has determined that miners are at significant risk of material harm at a TWA_8 of 85 dBA, but technological and feasibility considerations may preclude the industry as a whole, at this time, from eliminating exposures below a TWA_8 90 dBA. Accordingly, MSHA proposed that mine operators must take certain actions to limit miner exposure to noise above a TWA_8 of 85 dBA that are feasible (e.g., provide hearing exams and hearing protectors).

MSHA considered the establishment of a similar ''action level'' for dpm—probably at half the proposed concentration limit, or 80_{TC} $\mu g/m^3$. Under such an approach, mine operators whose dpm concentrations are above the ''action level'' would be required to implement a series of ''best practices''—e.g., limits on fuel types, idling, and engine maintenance. MSHA welcomes comments on whether it should take such an approach with dpm.

In lieu of this approach, the Agency decided instead to propose an approach that it believes will be simpler for the mining community to implement: requiring compliance with the ''best practices'' in all cases. There are several reasons why the agency has proposed this approach.

First, sampling by both operators and MSHA would have to be much more frequent if a measurement trigger for additional actions were to be established. This is because many more areas of a mine would need to be checked regularly than if only a higher trigger is in place. In underground metal and nonmetal mines, most areas using diesel equipment would exceed a limit of 75_{TC} µg/m^3 anyway, so the sampling needed to confirm the situation would appear to be wasteful.

Second, diesel equipment is often moving, meaning that maintenance and fleet requirements triggered by a single sample might switch on and off in ways that are hard to predict. Moreover, using an action level in an area of a mine to trigger maintenance requirements might put certain machines in the fleet under one set of maintenance rules and other machines under an alternative set, complicating mine administration.

Third, underground coal mines which use diesel-powered equipment already observe a set of such requirements. While certain special safety hazards associated with the use of diesel-powered equipment in underground coal mines warrant certain work practices that may not be warranted in other sectors, the safety rationale for adopting some of these practices seems as valid in other sectors as in underground coal. Fourth, given the history of the mining industry with lung problems associated with this type of work, adopting a prudent approach seems a wise course when the costs of prevention are limited. This is standard health practice.

Finally, a number of the work practices proposed appear to have significant benefits—improving the efficiency of mining operations by ensuring that diesel mining equipment is maintained in good working order to meet productivity demands.

MSHA specifically solicits comments from the public on whether or not it should require ''best practices'' to lower the dpm concentration.

(23) Will the Proposed Restrictions on Fuel and Fuel Additives Increase Costs or Limit Engine Reliability?

MSHA believes the answer to both questions is no.

Under proposed § 57.5065, mine operators would be able to use only low-sulfur diesel fuel. This requirement is identical to that for underground coal diesel equipment. Number 1 and number 2 diesel fuel would be permitted. MSHA has been advised that low-sulfur diesel fuel is now readily available in all areas of the country in order to meet EPA requirements; in many places, it is the only fuel available.

Similarly, the proposal would extend to all mines the ban in underground coal mines on the use of diesel-fuel additives other than those approved by EPA. There is a long list of approved additives. Copies are available from EPA and the list is posted on its Web site, or you may link to them from MSHA's Web site (http://www.msha.gov/s&hinfo/deslreg/1901(c).htm). Using only additives that have been approved ensures that diesel particulate concentrations are not inadvertently increased, while also protecting miners against the emission of other toxic substances.

(24) How Is MSHA Going To Distinguish Between Idling That Is Permitted and Idling That Isn't Permitted?

Keeping idling to a minimum is a very important way to reduce pollution in mine atmospheres, and this would be required by proposed § 57.5065(c). Idling engines can actually produce more pollutants than engines under load. Generally of more concern, however, is the impact idling engines can have on localized exposures. In underground operations, an engine idling in an area of minimal ventilation or a ''dead air'' space could cause an excess exposure to the gaseous emissions, especially carbon monoxide, as well as to diesel particulate. Eliminating unnecessary idling can make a substantial contribution toward preventing localized exposure to high particulate concentrations.

However, there are some circumstances in which idling is necessary. The proposal would permit idling in connection with ''normal mining operations''. In the proposal, MSHA does not attempt to define this term, and would intend this rule to be administered with reference to commonly understand practices of what is necessary idling. For example, idling while waiting for a load to be unhooked, or waiting in line to pick up a load, is normally part of the job; idling while eating lunch is normally not part of the job. But if the idling is necessary due to the very cold weather conditions, it should not be barred. On the other hand, idling should not be permitted in other weather conditions just to keep balky older engines running; in such cases, the correct approach is better maintenance. MSHA recognizes that to administer this provision in a common sense manner may require the provision of examples to both MSHA inspectors and to the mining community; accordingly, the Agency welcomes specific examples of circumstances where idling should and should not be permitted. The Agency recently implemented a similar provision for the underground coal mining sector, and MSHA will consider the experience gained under that rule in formulating a final diesel particulate rule and compliance guide.

(25) Will the Proposed Rule Require That Diesel Engines and Aftertreatment Devices Used in Underground Metal and Nonmetal Mines Be Maintained in Mint Condition?

No. § 57.5066(a) of the proposed rule would, however, require that the engines and aftertreatment devices not be permitted to deteriorate to the point they create needless pollution. The air intake system, the cooling system, lubrication system, fuel injection system and exhaust system of an engine must all be maintained on a regular schedule if the toxic contaminants in the engine exhaust are to be minimized. And there is little point in having an aftertreatment device to limit pollution if it is not maintained in working order; moreover, it can damage the engine. A good preventive maintenance program can not only keep down exhaust emissions, but help maximize vehicle productivity and engine life.

It is difficult for a rule covering all types and ages of engines used in underground metal and nonmetal mines to define precisely the level of maintenance required for each engine. Further, MSHA does not believe that it is necessary: the mining community is fully cognizant of the general requirements for engine maintenance. Accordingly, proposed § 57.5066(a) sets out in general terms the standard of care required for different types of engines.

First, an ''approved'' engine is to be maintained in approved condition. MSHA approves engines under specific regulations set forth in Title 30. The approval of the engine is tied to certain parts and specifications. When these parts or specifications are changed (e.g., an incorrect part is used, or the wrong setting), then the engine is no longer considered in approved condition. The requirements in this regard are well defined. MSHA personnel at the Approval Certification Center are available to the mining community to respond to questions and provide specific guidance. MSHA's diesel equipment rule already requires underground coal mine fleets to convert entirely to approved engines, but at this time only some of the engines used in underground metal and nonmetal mines are approved.

Second, for any engine that is not an approved engine, the ''emission related components'' of the engine are to be maintained to manufacturer specifications. By the term ''emission related components,'' MSHA means the parts of the engine that directly affect the emission characteristics of the raw exhaust. These are basically the same components which MSHA examines for ''approved'' engines. They are: the piston; intake and exhaust values; cylinder head; camshaft; injector; fuel injection pump; governor; injection timing and fuel pump calibration; and, if applicable, turbocharger and after cooler.

Third, and finally, any emission or particulate control device installed on diesel-powered equipment is to be maintained in ''effective operating condition.'' The maintenance of an emission or particulate control device in effective operating condition involves such basic tasks as regularly cleaning the filter using whatever methods are recommended by the manufacturer for that purpose or inserting appropriate replacement filters, checking for and repairing any leaks, and similar obvious actions.

An MSHA inspector is not going to randomly order an engine to be taken out of service and torn down to check the condition of a piston against the shop manual. Rather, what will concern an inspector are the same kinds of signals that should concern a conscientious operator—for example, a history of complaints about the engine's reliability, an incomplete maintenance schedule, lack of required maintenance manuals or spare parts, the emission of black smoke under normal load, or a series of emission test results indicating a continuing engine problem. Evidence of such deficiencies is likely to lead to a closer examination. But a conscientious maintenance program is going to catch such problems before they occur.

MSHA's toolbox includes an extensive discussion of maintenance. It reminds operators and diesel maintenance personnel of the basic systems on diesel engines that need to be maintained, and how to avoid various problems. It includes suggestions from others in the mining community, and information on their success or difficulties in this regard. MSHA will continue to provide technical assistance to the mining community in this critical area.

(26) What Are the Responsibilities of a Miner Who Operates Diesel-Powered Equipment in an Underground Metal and Nonmetal Mine To Ensure it Is Not Polluting? And What Are The Responsibilities of Mine Management When Notified of a Potential Pollution Problem?

The miner who operates diesel-powered equipment is often the first one to spot a problem with the engine or emissions system. The engine may balk, have trouble handling a load, make unusual noises, exhaust too much smoke, or otherwise suggest to the person familiar with the engine's capabilities that it needs to be checked. In some cases, the miner may have the knowledge, parts, equipment and authority to fix the problem on the spot. In many cases, however, the miner operating the equipment may not have all of these. If the problem is to be addressed promptly, it is essential the miner report it to mine management—and that the mine management act on that report in a timely manner. If these actions by miner and mine management are not taken, the concentrations of diesel particulate are likely to quickly increase without anyone being aware of the danger until the next environmental monitoring is performed. To avoid this problem, proposed § 57.5066 would require that all underground metal and nonmetal mines using diesel equipment underground implement a few basic procedures. The details of implementation in each mine would be at the discretion of the mine operator.

Proposed § 57.5066(b)(1) would require the mine operator to authorize the operator of diesel-powered equipment to affix a tag to the equipment at any time the equipment operator notes a potential problem. Tagging provides a simple mechanism for ensuring that all mine personnel are made quickly aware that a piece of equipment needs to be checked by qualified service personnel. The tag may be affixed because the equipment operator picks up a problem through a visual exam conducted before the equipment is started (e.g., an exam pursuant to 30 CFR 57.14100), or because of a problem that comes to the attention of the equipment operator during mining operations—e.g., black smoke while the equipment is under normal load, rough idling, unusual noises, backfiring, etc.

The proposal leaves the design of the tag to each mine operator, provided that the tag can be dated. Comments are welcome on whether some or all elements of the tag should be standardized to ensure its purpose is met.

MSHA is not proposing that equipment tagged for such potential emission problems be automatically taken out of service. The proposal is not, therefore, directly comparable to a ''tag-out'' requirement like OSHA's requirement for automatically powered machinery, nor as stringent as MSHA's requirement to remove from service certain equipment ''when defects make continued operation hazardous to persons'' (see, e.g., 30 CFR 57.14100). While the emissions problem could pose a serious health hazard for miners directly exposed, there is no way to determine this with certainty until the equipment is tested. Moreover, the danger is not as immediate as, for example, an explosive hazard. Rather, proposed § 57.5066(b)(2) would require that the equipment be ''promptly'' examined by a person authorized by the mine operator to maintain diesel equipment (the qualifications for those who maintain and service diesel engines discussed in response to the next question). The Agency has not tried to define the term ''promptly'', but welcomes comment on whether it should do so—in terms, for example, of a limited number of shifts.

The proposal would require that a single log be retained of all equipment tagged. The proposal would permit a tag to be removed after an examination has been completed and a record of the examination made—with the date, the name of the person making the examination, and the action taken as a result of the examination. The presence of a tag serves as a caution sign to miners working near the equipment, as well as a reminder to mine management, as the equipment moves from task to task throughout the mine. While the equipment is not barred from service, operators would be expected to use common sense in using it in locations in which diesel particulate concentrations are known to be high. The records of the tagging and servicing, although basic, provide mine operators, miners and MSHA a history that will help all of them evaluate whether a maintenance program is being effectively implemented.

(27) Must Miners or Others Who Examine or Repair Diesel Engines Used in Underground Metal and Nonmetal Mines Have Special Qualifications or Training? Must Operators Establish Programs or Criteria for This Purpose?

The answer to the first question is a qualified ''yes'', and the answer to the second question is no.

Proposed § 57.5066(c) provides that: ''Persons authorized by a mine operator to maintain diesel equipment covered by paragraph (a) of this section must be qualified, by virtue of training or experience, to ensure that the maintenance standards of paragraph (a) of this section are observed.'' As discussed in response to Question 25, paragraph (a) of § 57.5066 provides that approved engines be maintained in approved condition, the emission related components of non-approved engines be maintained to manufacturer specifications, and emission or particulate control devices installed on the equipment be maintained in effective condition.

This means that regardless of who identifies a potential problem along these lines, the person who checks out the problem, and if necessary makes repairs, is someone who knows what he or she is doing. If examining and, if necessary, changing a filter or air cleaner is what is needed, a miner who has been shown how to do these tasks would be ''qualified by virtue of training or experience'' to do those tasks. For more sophisticated work, more sophisticated training or additional experience would be required. Training by a manufacturer's representative, completion of a general diesel engine maintenance course, or practical experience performing such repairs might be evidence of appropriate qualifications.

In the underground coal sector, MSHA requires each operator to establish a program to ensure that persons who work on diesel engines are qualified. That is not being proposed for the underground metal and nonmetal sector. The unique conditions in underground coal mines require the use of specialized equipment. Accordingly, the qualifications of the persons who maintain this equipment generally must be more sophisticated than in other sectors.

The proposed rule contemplates that if MSHA finds a situation where maintenance appears to be shoddy or where tampering has damaged engine approval status or emission control effectiveness, MSHA will ask the operator to provide evidence that the person who worked on the equipment was properly qualified by virtue of training or experience. Equipment sent off site for maintenance and repair is just as subject to this requirement as other equipment; it is the operator's obligation to ensure he has appropriate evidence of the qualifications of those who will work on the equipment.

(28) Can Underground Metal and Nonmetal Operators Continue To Use and Relocate Nonapproved Engines in Their Inventories?

Pursuant to MSHA's diesel equipment rule, the entire fleet of underground coal engines must be ''approved'' engines by the year 2000—even if operators must replace existing engines to comply. By contrast, proposed § 57.5067 would only require that, with a few exceptions, all engines ''introduced'' into underground areas of underground metal and nonmetal mines after the effective date must be engines that have been through MSHA's approval process under Part 7 of Chapter 30. Operators who have significant investments in their existing fleets will accordingly be able to retain those engines, provided they are maintained in the manner specified in the proposal and that the concentration of diesel particulate can be controlled in another way (e.g. ventilation, particulate filters, etc.).

However, after the rule's effective date, an operator would not be permitted to bring into underground areas of a mine an unapproved engine from the surface area of the same mine, an area of another mine, or from a non-mining operation. Since the safe level of diesel particulate is not known, promoting a gradual turnover of the existing fleet is an appropriate response to the health risk presented.

Some engines currently used in metal and nonmetal mines may have no approval criteria; in such cases, MSHA will work with the manufacturers to develop approval criteria consistent with those MSHA uses for other diesel engines. Based upon preliminary analysis, MSHA has tentatively concluded that any diesel engine meeting current on-highway and non-road EPA emission requirements would meet MSHA's engine approval standards of Part 7, subpart E, category B type engine. (See Section 4 of Part II of this preamble for further information about these engines). Currently, the EPA nonroad test cycle and MSHA's test cycle are the same for determining the gaseous and particulate emissions. MSHA envisions being able to use the EPA test data ran on the non-road test cycle for determining the gaseous ventilation rate and particulate index. The engine manufacturer would continue to submit the proper paper work for a specific model diesel engine to receive the MSHA approval. However, engine data ran on the EPA on-highway transient test cycle would not as easily be usable to determine the gaseous ventilation and particulate index. Comments on how MSHA can facilitate review of engines not currently approved would be welcome.

Engines in diesel-powered ambulances and fire-fighting equipment would be exempted from these requirements. This exemption is identical with that in the rule for diesel-powered equipment in underground coal mines.

(29) What Specifically Would Be the Obligations of an Underground Metal or Nonmetal Mine Operator To Monitor dpm Exposures and to Correct Overexposures?

Proposed § 57.5071 would require underground metal or nonmetal mine operators to monitor the concentration of diesel particulate, to initiate corrective action by the next work shift if the monitoring reveals that the concentration of diesel particulate exceeds the permitted limit, and to post sample results and the corrective action being taken.

There is no prescribed frequency for monitoring. But proposed § 57.5071(a) provides that sampling must be done as often as necessary to ''effectively evaluate,'' under conditions that can be reasonably anticipated in the mine:

(1) whether the dpm concentration in any area of the mine where miners work or travel exceeds the applicable limit; and (2) the average full shift airborne concentration at any location or on any person designated by MSHA. The first condition clarifies that it is the responsibility of mine operators to be aware of the concentrations of diesel particulate in all areas of the mine where miners work or travel, so as to know whether action is needed to ensure that the concentration does not exceed the applicable limit. The second condition is to ensure special attention to locations or persons known to MSHA to have a significant potential for overexposure to diesel particulate.

The proposed rule is performance oriented in that the regularity and methodology used to make this evaluation are not specified. MSHA's own measurements will assist the Agency in verifying the effectiveness of an operator's monitoring program. If an operator is ''effectively evaluating'' the concentration of dpm at designated locations, for example, MSHA would not expect to record concentrations above the limit when it samples at that location. Some record of the sampling procedure and sample results will need to be retained by operators to establish that they have complied with the general obligations of this section.

The proposed rule requires, consistent with Section 103(c) of the Mine Act, that miners and their representatives have an opportunity to observe such monitoring. In accordance with this legal requirement, the proposed rule requires a mine operator to provide affected miners and their representatives with an opportunity to observe exposure monitoring of dpm by operators. Mine operators must give prior notice to affected miners and their representatives of the date and time of intended monitoring. MSHA has proposed similar language in its proposed rule on noise.

The proposed rule does not specify a required method for sampling. In the absence of a procedure to convert total carbon measurements into equivalents under other methods, methods other than NIOSH Method 5040 would not provide exact information about compliance status, but they certainly would provide a general guide to dpm concentrations if used under proper circumstances. (More information on the proper circumstances in which various methods are appropriate can be found in Section 3 of Part II of this preamble).

The proposed rule provides that an operator who has knowledge that a concentration limit has been exceeded must initiate corrective action by the next work shift and promptly complete such action. The hazards presented by overexposure to dpm may not as immediate as an explosive hazard, but are nevertheless serious. Accordingly, although MSHA is not proposing immediate withdrawal of miners nor even immediate completion of abatement action, the agency is proposing that mine operators begin abatement action by the next shift and promptly complete such action, not allowing it to drag out while miners are being overexposed. The Agency is also proposing to require posting of the corrective action to implement the statutory requirement that notice of corrective action be provided to miners. MSHA welcomes comment on how it might clarify its expectations with respect to the initiation of corrective action, including what specific guidance to provide to operators not using the total carbon method and as to when corrective action must begin when the analysis is performed on a delayed basis off-site. MSHA also welcomes comment as to whether personal notice of corrective action would be more appropriate than posting given the health risks involved.

Proposed § 57.5071(d) provides that monitoring results must be posted on the mine bulletin board, and a copy provided to the authorized representative of miners. As with the training requirements, posting ensures that miners are kept aware of the hazard so they can actively play their role in prevention.

(30) What Records Must be Kept by Metal and Nonmetal Operators? Where Must they be Kept, and Who Has Access to Them?

Recordkeeping and retention requirements are noted in the text of each section of the proposed rule creating the requirement. For the sake of convenience, a table of record-keeping requirements is provided in proposed § 57.5075(a). The table lists the records that would be required under the proposed changes to Part 57, notes the proposed section of Part 57 creating the recordkeeping requirement, and notes the type of record and retention time. MSHA would welcome comment on whether this presentation is useful.

In some cases, the record required is expressed in general terms: e.g., ''evidence of competence to perform maintenance'', pursuant to proposed § 57.5066(c). As long as each operator has some record that establishes this fact, it does not matter that the records of one operator are not the same as the records of another operator. While an MSHA inspector may well be willing to accept oral evidence on a particular point (e.g., who performed a repair), operators should retain written documentation adequate to demonstrate the facts involved (e.g., a logbook for each engine showing who worked on it, the date, the work performed, and any follow-up needs or plans). MSHA would welcome comments on whether the agency should be more specific as to the recordkeeping systems mine operators should utilize.

The proposed rule generally provides that records required be retained at the mine site. These records need to be where an inspector can view them during the course of an inspection, as the information in the records may determine how the inspection proceeds. But if the mine site has an operative fax machine or computer terminal, this section would permit the records to be maintained elsewhere. MSHA's approach in this regard is consistent with Office of Management and Budget Circular A–1. Mine operators must promptly provide access to compliance records upon request from an authorized representative of the Secretary of Labor, the Secretary of Health and Human Services, or from the authorized representative of miners. Access to a miner's sample records must also be provided to a miner, former miner, or personal representative of a miner—the first copy at no cost, and any subsequent copies at reasonable cost.

MSHA encourages mine operators who store records electronically to provide a mechanism which will allow the continued storage and retrieval of records in the year 2000.

II. Background Information.

This part provides the context for this rulemaking. The nine topics covered are:

(1) The role of diesel-powered equipment in mining;

(2) Diesel exhaust and diesel particulate;

(3) Methods available to measure dpm;

(4) Reducing soot at the source—engine standards;

(5) Limiting the public's exposure to soot—ambient air quality standards;

(6) Controlling diesel particulate emissions in mining—a Toolbox;

(7) Existing mining standards that limit miner exposure to occupational diesel particulate emissions;

(8) How other jurisdictions are restricting occupational exposure to diesel soot; and

(9) MSHA's initiative to limit miner exposure to diesel particulates—the history of this rulemaking and related actions.

In addition, a recent MSHA publication, ''Practical Ways to Reduce Exposure to Diesel Exhaust in Mining—A Toolbox'', contains considerable information of interest in this rulemaking. The ''Toolbox'' which includes additional information on methods for controlling dpm, and a glossary of terms, is appended to the end of this document.

These topics will be of interest to the entire mining community, even though this rulemaking is specifically confined to the underground metal and nonmetal sector.

(1) *The Role of Diesel-Powered Equipment in Mining.* Diesel engines now power a full range of mining equipment on the surface and underground, in both coal and in metal/nonmetal mining. Many in the mining industry believe that diesel-powered equipment has a number of productivity and safety advantages over electrically-powered equipment. Nevertheless, concern about miner safety and health has slowed the spread of this technology, and in certain states resulted in a complete ban on its use in

underground coal mines. As the industry has moved to realize the advantages this equipment may provide, the Agency has endeavored to address the miner safety and health issues presented.

Historical Patterns of Use. The diesel engine was developed in 1892 by the German engineer Rudolph Diesel. It was originally intended to burn coal dust with high thermodynamic efficiency. Later, the diesel engine was modified to burn middle distillate petroleum (diesel fuel). In diesel engines, liquid fuel droplets are injected into a prechamber or directly into the cylinder of the engine. Due to compression of air in the cylinder the temperature rises high enough in the cylinder to ignite the fuel.

The first diesel engines were not suited for many tasks because they were too large and heavy (weighing 450 lbs. per horsepower). It was not until the 1920's that the diesel engine became an efficient lightweight power unit. Since diesel engines were built ruggedly and had few operational failures, they were used in the military, railway, farm, construction, trucking, and busing industries. The U.S. mining industry was slow, however, to begin using these engines. Thus, when in 1935 the former U.S. Bureau of Mines published a comprehensive overview on metal mine ventilation (McElroy, 1935), it did not even mention ventilation requirements for diesel-powered equipment. By contrast, the European mining community began using these engines in significant numbers, and various reports on the subject were published during the 1930's. According to a 1936 summary of these reports (Rice, 1936), the diesel engine had been introduced into German mines by 1927. By 1936, diesel engines were used extensively in coal mines in Germany, France, Belgium and Great Britain. Diesel engines were also used in potash, iron and other mines in Europe. Their primary use was in locomotives for hauling material.

It was not until 1939 that the first diesel engine was used in the United States mining industry, when a diesel haulage truck was used in a limestone mine in Pennsylvania. In 1946 diesel engines were introduced in coal mines. Today, however, diesel engines are used to power a wide variety of equipment in all sectors of U.S. mining, such as: air compressors; ambulances; crane trucks; ditch diggers; foam machines; forklifts; generators; graders; haul trucks; load-haul-dump machines; longwall retrievers; locomotives; lube units; mine sealant machines; personnel cars; hydraulic pump machines; rock dusting machines; roof/floor drills; shuttle cars; tractors; utility trucks; water spray units and welders.

Estimates of Current Use. Estimates of the current inventory of diesel engines in the mining industry are displayed in Table II–1. Not all of these engines are in actual use. Some may be retained rather than junked, and others are spares. MSHA has been careful to take this into account in developing cost estimates for this proposed rule; its assumptions in this regard are detailed in the Agency's PREA.

TABLE II–1.—DIESEL EQUIPMENT IN THREE MINING SECTORS

Mine type	# Mines [2]	# Mines w/ diesel	# Engines
Underground Coal	971	[3] 173	[4] 2,950
Small [1]	426	15	50
Large	545	158	2,900
Underground M/NM	261	203 [5]	[6] 4,100
Small [1]	130	82	625
Large	131	121	3,475
Surface Coal	1,673	[7] 1,673	[8] 22,000
Small [1]	1,175	1,175	7,000
Large	498	498	15,000
Surface M/NM	10,474	[9] 10,474	[10] 97,000

Notes on Table II–1:

(1) A mine with less than 20 miners. MSHA traditionally regards mines with less than 20 miners as ''small'' mines, and those with 20 or more miners as ''large'' mines based on differences in operation. However, in examining the impact of the proposed regulations on the mining community, MSHA, consistent with the Small Business Administration definition for small mines, which refers to employers with 500 employees or less, has analyzed impact for this size. This is discussed in the Agency's preliminary regulatory economic analysis for this proposed rule.
(2) Preliminary 1996 MSHA data.
(3) Data from MSHA approval and certification center, Oct. 95.
(4) Actual inventory, rounded to nearest 50.
(5) Estimates are based on a January 1998 count, by MSHA inspectors, of underground mines that use diesel powered equipment.
(6) The estimates are based on a January 1998 count, by MSHA inspectors, of diesel powered equipment normally in use.
(7) Based on assumption that all surface coal mines had some diesel powered equipment.
(8) Based on MSHA inventory of 25% of surface coal mines.
(9) MSHA assumes all surface M/NM mines use some diesel engines.
(10) Derived by applying ratios (engines per mine) from MSHA inventory of surface coal mines to M/NM mines.

As noted in Table II–1, a majority of underground metal and nonmetal mines, and all surface mines, use diesel-powered equipment. This is not true in underground coal mines—in no small measure because, as discussed later in this part, several key underground coal states have for many years banned the use of diesel-powered equipment in such mines.

Neither the diesel engines nor the diesel-powered equipment are identical from sector to sector. This relates to the equipment needs in each sector. This is important information because the type of engine, and the type of equipment in which it is installed, can have important consequences for particulate production and control.

As the horsepower size of the engine increases, the mass of dpm emissions produced per hour increases. (A smaller engine may produce the same or higher levels of particulate emissions per volume of exhaust as a large engine, due to the airflow, but the mass of particulate matter increases with the engine size). Accordingly, as engine size increases, control of emissions may require additional efforts.

Diesel engines in metal and nonmetal underground mines, and in surface coal mines, range up to 750 HP or greater; by contrast, in underground coal mines, the average engine size is less than 150 HP. The reason for this disparity is the nature of the equipment powered by diesel engines. In underground metal and nonmetal mines, and surface mines, diesel engines are widely used in all types of equipment — both the equipment used under the heavy stresses of production and the equipment used for support. By contrast, the great majority of the diesel usage in underground coal mines is in support equipment. For example, in underground metal and nonmetal mines, of the approximate 4,100 pieces of diesel equipment normally in use, about 1,800 units are for loading and hauling. By contrast, of the approximate 3,000 pieces of diesel equipment in underground coal, MSHA estimates that less than 50 pieces are for coal haulage. The largest diesel engines are used in surface operations; in underground metal and nonmetal mines, the size of the engine can be limited by the size of the shaft opening.

The type of equipment in the sectors also varies in another way that can affect particulate control directly, as well as constrain engine size. In underground coal, equipment that is used in face (production) areas of the coal mine must be MSHA-approved Part 36 permissible equipment. These locations are the areas where methane gas is likely to accumulate in higher concentrations. This includes the in-by section starting at the tailpiece (coal dump point) and all returns. Part 36 permissible equipment for coal requires the use of flame arresters on the intake and exhaust systems and surface temperature control to below 302°F. As discussed in more detail elsewhere in this notice, the cooler exhaust from these permissible pieces of equipment permits the direct installation of particulate filtration devices such as paper type filters that cannot be used directly on engines with hot exhaust. In addition, the permissibility requirements have had the effect of limiting engine size. This is because prior to MSHA's issuance of a diesel equipment rule in 1996, surface temperature control was done by water jacketing. This limited the horsepower range of the permissible engines because manufacturers have not expended resources to develop systems that could meet the 302°F surface temperature limitation using a water jacketed turbocharger.

In the future, larger engines may be used on permissible equipment, because the new diesel rule allows the use of new technologies in lieu of water jacketing. This new technology, plus the introduction of air-charged aftercoolers on diesel engines, may lead to the application of larger size diesel engines for underground coal production units. Moreover, if manufacturers choose to develop this type of technology for underground coal production units, the number of diesel production machines may increase.

There are also a few underground metal and nonmetal mines that are gassy, and these require the use of Part 36 permissible equipment. Permissible equipment in metal and nonmetal mines must be able to control surface temperatures to 400°F. MSHA estimates that there are currently less than 15 metal and nonmetal mines classified as gassy and which, therefore, must use Part 36 permissible equipment if diesels are utilized in areas where permissible equipment is required. These gassy metal and nonmetal mines have been using the same permissible engines and power packages as those approved for underground coal mines. (MSHA has not certified a diesel engine exclusively for a Part 36 permissible machine for the metal and nonmetal sector since 1985 and has certified only one permissible power package; however, that engine model has been retired and is no longer available as a new purchase to the industry). As a result, these mines are in a similar situation as underground coal mines: engine size (and thus dpm production of each engine) is more limited, and the exhaust is cool enough to add the paper type of filtration device directly to the equipment.

In nongassy underground metal and nonmetal mines, and in all surface mines, mine operators can use conventional construction equipment in their production sections without the need for modifications to the machines. Two examples are haulage vehicles and dump trucks. Some construction vehicles may be redesigned and articulated for sharper turns in underground mines; however, the engines are still the industrial type construction engines. As a result, these mines can and do use engines with larger horsepower. At the same time, since the exhaust is not cooled, paper-type filters cannot be added directly to this equipment without first adding a water scrubber, heat exchanger or other cooling device. The same is true for the equipment used in outby areas of coal mines, where the methane levels do not require the use of permissible equipment.

Future Demand and Emissions. MSHA expects there will be more diesel-powered equipment added to the Nation's mines. While other types of power sources for mining equipment are available, many in the mining industry believe that diesel power provides both safety and economic advantages over alternative power sources available today. Not many studies have been done recently on these contentions, and the studies which have been reviewed by MSHA do not clearly support this hypothesis; but as long as this view remains prevalent, continued growth is likely.

There are additional factors that could increase growth. As noted above, permissible equipment can now be designed in such a way to permit the use of larger engines, and in turn more use of diesel-powered production equipment in underground coal and other gassy mines. Moreover, state laws banning the use of diesel engines in the underground coal sector are under attack. As noted in section 8 of this part, until recently, three major underground coal states, Pennsylvania, West Virginia, and Ohio, have prohibited the use of diesel engines in underground coal mines. In late 1996, Pennsylvania passed legislation (PA Senate Bill No. 1643) permitting such use under conditions defined in the statute. West Virginia passed legislation lifting its ban as of May, 1997 (WV House Bill 2890), subject to regulations to be developed by a joint labor-industry commission. This makes the need to address safety and health concerns about the use of such engines very pressing.

In the long term, the mining industry's diesel fleet will become cleaner, even if the size of the fleet expands. This is because the old engines will eventually be replaced by new engines that will emit fewer particulates than they do at present. As discussed in Section 4 of this part, EPA regulations limiting the emissions of particulates and various gasses from new diesel engines are already being implemented for some of the smaller engines used in mining. Under a defined schedule, these new standards will soon apply to other new engines, including the larger engines used in mining. Moreover, over time, the emission standards which new engines will have to pass will become more and more stringent. Under international accords, imported engines are also likely to be cleaner: European countries have already established more stringent emission requirements (Needham, 1993; Sauerteig, 1995).

Based on the feasibility using the estimator, new engine technology, catalytic converters, and current ventilation should reduce dp levels down below the $400_{TC}um^3$. However, to reduce to the $160_{TC}um^3$ level, dp filters or cabs will still be needed on a certain number of equipment, based on mining conditions and diesel usage. The particulate index values listed for the MSHA approved engines provides information on the dp emissions and also can be used to help determine how low engine technology alone can lower dp exposures. When filters are used, the cleaner engines allow the filters to last longer between change out or cleaning. The newer technology engines, especially the electronic models, also add the benefit of diagnostic control. The engines computer can inform the mechanic on the condition of the engine and warn the mechanic when an engine is in need of maintenance.

But MSHA believes that turnover of the mining fleet to these new, cleaner engines will take a very long time because the mining industry tends to purchase for mining use older equipment that is being discarded by other industries. In the meantime, the particulate burden on miners as a group is expected to remain at current levels or even grow.

(2) *Diesel Exhaust and Diesel Particulate.* The emissions from diesel engines are actually a complex mixture of compounds, containing gaseous and particulate fractions. The specific composition of the diesel exhaust in a mine will vary with the type of engines being used and how they are used. Factors such as type of fuel, load cycle, engine maintenance, tuning, and exhaust treatment will affect the composition of both the gaseous and particulate fractions of the exhaust. This complexity is compounded by the multitude of environmental settings in which diesel-powered equipment is operated. Elevation, for example, is a factor. Nevertheless, there are a few basic facts about diesel emissions that are of general applicability.

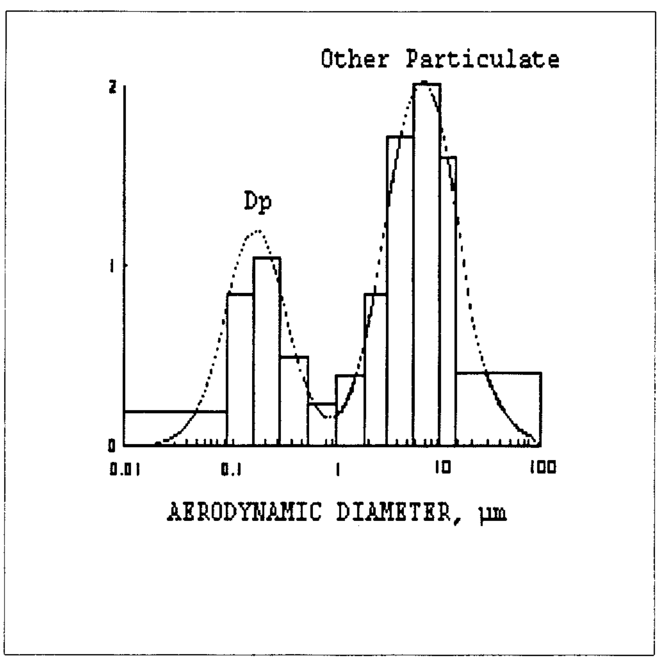
The gaseous constituents of diesel exhaust include oxides of carbon, nitrogen and sulfur, alkanes and alkenes (e.g., butadiene), aldehydes (e.g., formaldehyde), monocyclic aromatics (e.g., benzene, toluene), and polycyclic aromatic hydrocarbons (e.g., phenanthrene, fluoranthene). The oxides of nitrogen (NO_x) are worth particular mention because in the atmosphere they can precipitate into particulate matter. Thus, controlling the emissions of NO_x is one way that engine manufacturers can control particulate production indirectly. (See Section 4 of this part.)

The particulate fraction of diesel exhaust—what is known as soot—is made up of very small individual particles. Each particle consists of an insoluble, elemental carbon core and an adsorbed, surface coating of relatively soluble organic carbon (hydrocarbon) compounds. There can be up to 1,800 different organic compounds adsorbed onto the elemental carbon core. A portion of this hydrocarbon material is the result of incomplete combustion of fuel; however, the majority is derived from the engine lube oil. In addition, the diesel particles contain a fraction of non-organic adsorbed materials.

Diesel particles released to the atmosphere can be in the form of individual particles or chain aggregates (Vuk, Jones, and Johnson, 1976). In underground coal mines, more than 90% of these particles and chain aggregates are submicrometer in size—i.e., less than 1 micrometer (1 micron) in diameter. In underground metal and nonmetal mines, a greater portion of the aggregates may be larger than 1 micron in size because of the equipment used. Dust generated by mining and crushing of material—e.g., silica dust, coal dust, rock dust—is generally not submicrometer in size.

Figure II–1 shows a typical size distribution of the particles found in the environment of a mine that uses equipment powered by diesel engines (Cantrell and Rubow, 1992). The vertical axis represents relative concentration, and the horizontal axis the particle diameter. As can be seen, the distribution is bimodal, with dpm generally being well less than 1 µm in size and dust generated by the mining process being well greater than 1 µm. Because of their small size, even when diesel particles are present in large quantities, the environment might not be perceived as ''dusty''. Rather, the perception might be primarily of a vaporous, dirty and smelly ''soot'' or ''smoke''.

Figure II-1 -Typical distribution of dpm relative to distribution of other mining particulates.



The particulate nature of diesel soot has special significance for the mining community, which has a history of significant health and safety problems associated with dusts in the mining atmosphere. As a result of this long experience, the mining community is familiar with the standard techniques to control particulate concentrations. It knows how to use ventilation systems, for example, to reduce dust levels in underground mines. It knows how to water down particulates capable of being impacted by that approach, and to divert particulates away from where miners are actively working. Moreover, the mining community has long experience in the sampling and measurement of particulates—and in all the problems associated therewith. Miners and mine operators are very familiar with sampling devices that are worn by miners during normal work activities or placed in specific locations to collect dust. They understand the significance of sample integrity, the validity of laboratory analysis, and the concept of statistical error in individual samples. They know that weather and mine conditions can affect particulate production, as can changes in mine operations in an area of the mine. MSHA and the former Bureau of Mines have conducted considerable research into these topics. While the mining community has often argued over these points, and continues to do so, the sophistication of the arguments reflects the thorough familiarity of the mining community with particulate sampling and analysis techniques.

(3) *Methods Available to Measure DPM.* There are a number of methods which can measure dpm concentrations with reasonable accuracy when it is at high concentrations and when the purpose is exposure assessment. Measurements for the purpose of compliance determinations must be more accurate, especially if they are to measure compliance with a dpm concentration as low as 200 $\mu g/m^3$ or lower. It is with these considerations in mind that MSHA has carefully analyzed the available methods for measuring dpm.

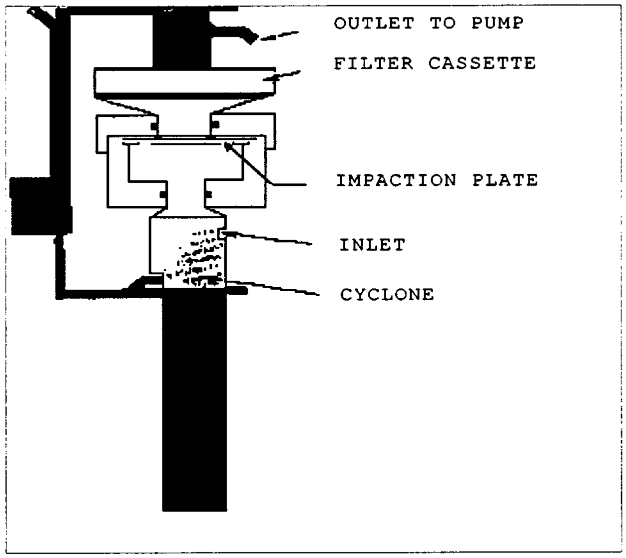
Comments. In its advanced notice of proposed rulemaking (ANPRM) in 1992, MSHA sought information on whether there are methodologies available for assessing occupational exposures to diesel particulate.

Some commenters argued that at that time there was no validated sampling method for diesel exhaust and there had been no valid analytical method developed to determine the concentration of diesel exhaust. According to the American Mining Congress, (AMC 1992), sampling methods commonly in use were prototypic in nature, were primarily being utilized by government agencies and were subject to interference. Commenters also stated that sampling instrumentation was not commercially available and that the analytical procedures could only be conducted in a limited number of laboratories. Several industry commenters submitted results of studies to support their position on problems with measuring diesel particulate in underground mines. A problem with sampler performance was noted in a study using prototype dichotomous sampling devices. Another commenter indicated that the prototype sampler developed by the former Bureau of Mines (discussed later in this section) for collecting the submicrometer respirable dust was difficult to assemble but easy to use, and that no problems were encountered. Problems associated with gravimetric analysis were also noted in assessing a short term exposure limit (STEL). Another commenter (Morton, 1992) indicated the cost of the sampling was prohibitive.

Another issue addressed by commenters to the 1992 ANPRM was ‘‘Are existing sampling and exposure monitoring methods sufficiently sensitive, accurate and reliable?’’ If not, what methods would be more suitable? Some commenters indicated their views that sampling methods had not been validated at that time for compliance sampling. They asserted that, depending on the level of measurement, both the size selective and elemental carbon techniques have some utility. The measurement devices give a precise measurement; however, because of interferants, corrections may need to be made to obtain an accurate measurement. Commenters also expressed the view that all of the sampling devices are sophisticated and require some expertise to assemble and analyze the results, and that MSHA should rely on outside agencies to evaluate and validate the sampling methods. An on-board sampler being developed by Michigan Technological University was the only other emission measurement technology discussed in the comments. However, this device is still in the development stage. Another commenter indicated that the standard should be based on the hazard and that the standard would force the development of measurement technology.

Submicrometer Sampling. The former Bureau of Mines (BOM) submitted information on the development of a prototype dichotomous impactor sampling device that separates and collects the submicrometer respirable particulate from the respirable dust sampled (See Figure II–2).

Figure II- 2
Personal Sampler For Submicrometer
Particulate Sampling



The sampling device was designed to help measure dpm in coal mine environments, where, as noted in the last section of this part, nearly all the dpm is submicrometer (less than 1 micron) in size. In its submission to MSHA, the former BOM noted it had redesigned a prototype and had verified the sampler's performance through laboratory and field tests.

As used by the former BOM in its research, the submicrometer respirable particulate was collected on a pre-weighed filter. Post-weighing of the filter provides a measure of the submicrometer respirable particulate. The relative insensitivity of the gravimetric method only allows for a lower limit of detection of approximately 200 $\mu g/m^3$.

Because submicrometer respirable particulate can contain particulate material other than diesel particulate, measurements can be subject to interference from other submicrometer particulate material.

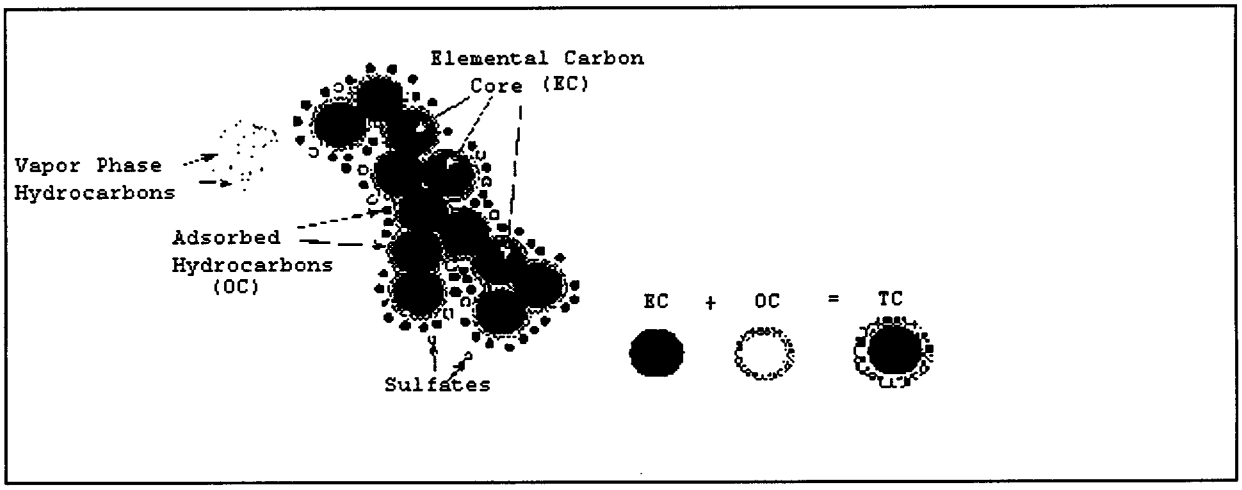
NIOSH Method 5040. In response to the ANPRM, NIOSH submitted information relative to the development of a sampling and analytical method to assess the diesel particulate concentration in an environment by measuring the amount of total carbon.

As discussed earlier in this part, diesel particulate consists of a core of elemental carbon (EC), adsorbed organic carbon (OC) compounds, sulfates, vapor phase hydrocarbons and traces of other compounds. The method developed by NIOSH provides for the collection of a sample on a quartz fiber filter. The filter is mounted in an open face filter holder that allows for the sample to be uniformly deposited on the filter surface. After sampling, a section of the filter is analyzed using a thermal-optical technique (Birch and Cary, 1996). This technique allows the EC and OC species to be separately identified and quantified. Adding the EC and OC species together provides a measure of the total carbon concentration in the environment. This is indicated diagrammatically in Figure II–3.

Studies have shown that the sum of the carbon (C) components (EC+OC) associated with dpm accounts for 80–85% of the total dpm concentration when low sulfur fuel is used (Birch and Cary, 1996). Since the TC:DPM relationship is consistent, it provides a method for determining the amount of dpm.

The method can detect as little as 1 µ g/m3 of TC. Moreover, NIOSH has investigated the method and found it to meet NIOSH's accuracy criterion (NIOSH, 1995); i.e., that measurements come within 25 percent of the true TC concentration at least 95 percent of the time.

Figure II-3
DPM components



NIOSH Method 5040 is directly applicable for the determination of diesel particulate levels in underground metal and nonmetal mines. The only potential sources of carbon in such mines would be organic carbon from oil mist and cigarette smoke. Oil mist may occur when diesel equipment malfunctions or is in need of maintenance.

MSHA, currently, has no data as to the frequency of occurrence or the magnitude of the potential interference from oil mist. However, during studies conducted by MSHA to evaluate different methods used to measure diesel particulate concentrations in underground mines, MSHA has not encountered situations where oil mist was found to be an interferant. Moreover, the Agency assumes that full operator implementation of maintenance standards to minimize dpm emissions (which are part of MSHA's proposed rule) will minimize any remaining potential for such interference. MSHA welcomes comments or data relative to oil mist interference. Cigarette smoke is under the control of operators, during sampling times in particular, and hence should not be a consideration.

While samples in underground metal and nonmetal mines could be taken with a submicrometer impactor, this could lead to underestimating the total amount of dpm present. This is because the fraction of dpm particles greater than 1 micron in size in the environment of noncoal mines can be as great as 20% (Vuk, Jones, and Johnson, 1976).

When sampling diesel particulate in coal mines, the NIOSH method recommends that a specialized impactor with a submicrometer cut point, such as the one developed by the former BOM, be used. Use of the submicron impactor minimizes the collection of coal particles, which have an organic carbon content. However, if 10% of coal particles are submicron, this means that up to 200 micrograms of submicrometer coal dust could be collected in face areas under current coal dust standards. Accordingly, for samples collected in underground coal mines, an adjustment may have to be made for interference from submicrometer coal dust; however, outby areas where little coal mine dust is present may not need such an adjustment.

NIOSH further recommends that in using its method in coal mines, the sample only be analyzed for the EC component. Measuring only the EC component ensures that only diesel particulate material is being measured in such cases. However, there are no established relationships between the concentration of EC and total dpm under various operating conditions. (The organic carbon component of dpm can vary with engine type and duty cycle; hence, the amount of whole dpm present for a measured amount of EC may vary). The Agency welcomes data and suggestions that would help it ascertain if and how measurements of submicrometer elemental carbon could realistically be used to measure dpm concentrations in underground coal mines.

Although NIOSH Method 5040 requires no specialized equipment for collecting a dpm sample, the sample would most probably require analysis by a commercial laboratory. MSHA recognizes that the number of laboratories currently capable of analyzing samples using the thermal-optical method is limited. However, there are numerous laboratories available that have the ability to perform a TC analysis without identifying the different species of carbon in the sample. Total carbon determinations using these laboratories would provide the mine with good information relative to the levels of dpm to which miners are potentially exposed. MSHA believes that once there is a need (e.g., as a result of the requirements of the proposed rule), more commercial laboratories will develop the capability to analyze dpm samples using the thermo-optical analytical method. Currently, the cost to analyze a submicrometer particulate sample for its TC content ranges from $30 to $50. This cost is consistent with costs associated with similar analysis of minerals such as quartz.

RCD Method. Another method, referred to as the Respirable Combustible Dust Method (RCD), has been developed in Canada for measuring dpm concentrations in noncoal mines. Respirable dust is collected with a respirable dust sampler consisting of a 10 millimeter nylon cyclone and a filter capsule containing a preweighed, preconditioned silver membrane filter. Samples are collected at a flow rate of 1.7 liters per minute. The respirable sample collected includes both combustible and noncombustible particulate matter.

Samples collected in accordance with the RCD method require analysis by a commercial laboratory. Total respirable dust is determined gravimetrically by weighing the filter after the sample is collected. After the sample has been subjected to a controlled combustion process at 400 °C for two hours, the remainder of the sample is weighed, and the amount of the particulate burned off determined by subtraction. This is the RCD. The combustible particulate matter consists of the soluble organic fraction, the EC core of the dpm, and any other combustible material collected. Thus, only a portion of the RCD is attributable to dpm. Oil mist and other combustible matter collected on the filter are interferants that can affect the accuracy of dpm concentration determination using this method. Because the mass of RCD is determined by weighing, the relative insensitivity of this method is similar to that obtained with the size selective gravimetric method (approximately 200 $\mu g/m^3$).

One commenter (Inco Limited) indicated experience with this method for identifying diesel particulate in their mining operations and suggested that this technique may be appropriate for determining eight hour exposures. Although this method was commonly used by the commenter for assessing dpm levels, concerns for the efficiency of the cyclones used to sample the respirable fraction of the particulate along with interference from oil mist were expressed.

Canada is now experimenting with the use of a submicron impactor with the RCD method.

Sampler Availability. The components for conducting sampling according to the submicrometer and the RCD methods are commercially available, as are those for NIOSH Method 5040, without a submicrometer particulate separator (impactor).

A reusable impactor can be manufactured by machine shops following the design specifications developed by the former U.S. Bureau of Mines (BOM IC 9324, 1992). The use of the size-selective samplers requires some training and laboratory time to prepare the impaction plate and assemble the unit. The cost to manufacture the size-selective units is approximately $35.

In addition, MSHA has requested NIOSH to develop and provide a commercially available disposable submicrometer particulate separator that would be used with existing personal respirable dust sampling equipment. The commercially available separator will be manufactured according to design criteria specified by NIOSH. It is anticipated that other sampling instrument manufacturers will develop commercial units once there is an established need for such a sampling device.

Use of Alternative Surrogates to Assess DPM Concentrations. A number of commenters on the ANPRM indicated that a number of surrogates were available to monitor diesel particulate. Of the surrogates suggested, the most desirable to use would be carbon dioxide because of its ease of measurement. In 1992 the former Bureau of Mines (BOM IC 9324, 1992) reported on research being conducted to investigate the use of CO_2 as a surrogate to assess mine air quality where diesel equipment is utilized. However, because the relationship between CO_2 and other exhaust components depends on the number, type and duty cycle of the engines in operation, no acceptable measurement method based on the use of CO_2 has been developed.

(4) *Reducing Soot at the Source—Engine Standards.* One way to limit diesel particulate emissions is to redesign diesel engines so they produce fewer pollutants. Engine manufacturers around the world are being pressed to do this pursuant to environmental regulations. These cleaner engine requirements are sometimes referred to as tailpipe standards because compliance is measured by checking for pollutants as the exhaust emerges from the engine's tailpipe—before any aftertreatment devices. This section reviews developments in this area, and explains the relationship between the environmental standards on new engines and MSHA engine ''approval'' requirements.

The Clean Air Act and Mobile Sources. The Clean Air Act authorized the Federal Environmental Protection Agency (EPA) to establish nationwide standards for new mobile vehicles, including those powered by diesel engines. These standards are designed, over time, to reduce the volume of certain harmful atmospheric pollutants emanating from mobile sources: particulate matter, nitrogen oxides (which as previously noted, can result in the generation of particulates in the atmosphere), hydrocarbons and carbon monoxide.

California has its own standards. New engines destined for use in California must meet standards under the law of that State. The standards are issued and administered by the California Air Resources Board (CARB). In recent years, EPA and CARB have worked together with industry in establishing their respective standards, so most of them are identical.

Regulatory responsibility for implementation of the Clean Air Act is vested in the Office of Mobile Sources (OMS), part of the Office of Air and Radiation of the EPA. Some of the discussion which follows was derived from materials which can be accessed from the OMS home page on the World Wide Web at (http://www.epa.gov/docs/omswww/omshome.htm). Information about the CARB standards may be found at the home page of that agency at (http://www.arbis.arb.ca.gov/homepage.htm).

Engines are generally divided into three broad categories for purposes of environmental emissions standards, in accordance with the primary use for which the type of engine is designed: (1) cars and light duty trucks (i.e., to power passenger transport); (2) heavy duty trucks (i.e., to power over-the-road hauling); and (3) nonroad vehicles (i.e., to power small equipment, construction equipment, locomotives and other non-highway uses). Engines used in mining equipment are not regulated as a separate category in this regard, but engines in all three categories are engaged in mining work, from generator sets to pickup trucks to huge earth movers and haulers.

New vs. Used. The environmental tailpipe requirements are applicable only to new engines. In the mining industry, used engines are often purchased; and, of course, the existing fleet consists of engines that are not new. Thus, although these tailpipe requirements will bring about gradual reduction in the overall contribution of diesel pollution to the atmosphere, the beneficial effects on mining atmospheres may require a longer timeframe, absent actions to accelerate the turnover of mining fleets to the cleaner engines.

In underground coal mining, MSHA has already taken actions which will have such an effect on the fleet. The diesel equipment rule issued in late 1996 requires that by November 25, 1999, all diesel equipment used in underground coal mines use an approved engine and maintain that engine in approved condition (30 CFR 75.1907). MSHA expects this will result in the replacement of about 47 percent of the diesel engines now in the underground coal mine inventory with engines that emit fewer pollutants. The timeframe permitted for the turnover was based upon MSHA's estimates of the useful life in an underground mining environment of the ''outby'' equipment involved.

Technology-Forcing Schedule. As noted above, the exact environmental tailpipe requirements which a new diesel engine must meet varies with the date of manufacture. The Clean Air Act, which was most recently amended in 1990, establishes a schedule for the reduction of particular pollutants from mobile sources. EPA and CARB, working closely with the diesel engine industry, have endeavored to turn this into a regulatory schedule that forces technology while taking into account certain technological realities (e.g., actions taken to reduce particulate emissions may increase NO_X emissions, and vice versa). Existing EPA regulations for on-highway engines (both for light duty vehicles and heavy duty trucks) and non-road engines schedule the tailpipe standards that must be met for the rest of this century. Agreements between EPA, CARB and the engine industry are now leading to proposed rules for engine standards to be met during the early part of the next century. These standards will be stricter and will lower the levels of diesel emissions.

Light-Duty Engines. The current regulations on light duty vehicle engines (cars and passenger trucks) were set in 1991 (56 FR 25724). EPA is currently considering proposing new standards for this category. Pursuant to a specific requirement in the Clean Air Act Amendments of 1990, EPA is to study and report to Congress on whether further reductions in this category should be pursued. A public workshop was held in the Spring of 1997. EPA plans provide for a draft report to be available for public comment by Spring of 1998, and a final report completed by July 1998, although a notice of citizen suit has been filed to speed the process. Up-to-date information about the progress of this initiative can be found at the home page for the study (http://www.epa.gov/omswww/tr2home.htm).

On-highway Heavy Duty Truck Engines. The first phase of the on-highway standards for heavy duty diesel engines was applicable to engines manufactured in 1985 (40 CFR 86.085–11). For the first time, separate standards for nitrogen oxide (NO_X) and hydrocarbons (HC) were established. The nitrogen oxides and hydrocarbons are precursors of ground level ozone, a major component of smog. A number of hydrocarbons are also toxic, while nitrogen oxides contribute to the formation of acid rain and can, as previously noted, precipitate into particulate matter. In 1988, a specific standard limiting particulate matter emitted from the heavy duty on-highway diesel engines went into effect (40 CFR 86.088–11). The Clean Air Act Amendments and the regulations provided for phasing in even tighter controls on NO_X and particulate matter through 1998. Reductions in NO_X took place in 1990 and 1991 and are to occur again in 1998, and reductions in PM took place in 1991 and 1994. Certain types of trucks in particularly polluted urban areas must reach even tighter requirements.

On October 21, 1997, EPA issued a new rule for on-highway engines that will take effect for engine model years starting in 2004 (62 FR 54693). The rule establishes a combined requirement for NO_X and HC. The combined standard is set at 2.5gm/bhp-hr, which includes a cap of 0.5gm/bhp-hr for HC. Prior to the rule, the EPA, CARB, and the engine manufacturers signed a Statement of Principles (SOP) that agreed on harmonization of the emission standards and the feasible levels that could be achieved. The rule allows manufacturers a choice of two combinations of NO_X and HC, with a net expected reduction in NO_X emissions of 50%. The rule does not require further reductions in tailpipe emissions of PM.

Non-road Engines. Of particular interest to the mining community is the EPA's regulatory work on the standards that will be applicable to non-road engines, for these include the engines used in the heaviest mining equipment.

The 1990 Clean Air Act Amendments specifically directed EPA to study the contribution of nonroad engines to air pollution, and regulate them if warranted. In 1991, EPA released a study that documented higher than expected emission levels across a broad spectrum of nonroad engines and equipment (EPA Fact Sheet, EPA420–F–96–009, 1996). In response, EPA initiated several regulatory programs. One of these set emission standards for land-based nonroad engines greater than 50 horsepower (other than for rail use). Limits are established for tailpipe emissions of hydrocarbons, carbon monoxide, NO_X, and dpm. The limits are phased in from 1996 to 2000: starting in 1996 with nonroad engines from 175 to 750 hp, then smaller engines, and by 2000 the larger nonroad engines. Moreover, in February 1997, restrictions on nonroad engines for locomotives were proposed (62 FR 6366).

In September 1996, EPA announced another Statement of Principles (SOP) with the engine industry and CARB on new rounds of restrictions for non-road engines to begin to take place in this century. This led in September 1997 to a proposed rule setting standards for almost all types of engines in this category manufactured after 1999–2006 (the actual year depends on the category) (62 FR 50151). The applicable standards for an engine category would be gradually tightened through three tiers. They would set a cap on the combined NO_X and HC (similar to the on-highway), set CO standards, and lower standards on PM. The implementation of the final tier of the proposed reductions is subject to a technology review in 2001 to ensure that the appropriateness of the levels to be set is feasible.

Will the Diesel Engine Industry Meet Mining Industry Requirements? Concern has been expressed from time to time that the diesel industry might not be able to meet the ever tightening standards on tailpipe emissions, and might, therefore, stop producing certain engines needed by the mining community or other industries (Gushee, 1995). To date, however, such concerns have not been realized. The fact that the most recent regulations have been developed through a consensus process with the engine industry, and that the non-road plan includes a scheduled technology review to ensure the proposed emission standards can really be achieved, suggests that although the EPA standards are technology forcing, diesel engines will continue to be available to meet the needs of the mining community for the foreseeable future. In addition, the nonroad engine agreement with the industry calls for development of a separate research agreement involving stakeholders in the exploration of technologies that can achieve very low emission levels of NO_X and PM ''while preserving performance, reliability, durability, safety, efficiency, and compatibility with nonroad equipment'' (EPA420–F–96–015, September 1996). Also, Vice President Gore has recently noted that the Administration is committed to emissions research that would clean up both the diesels currently on the road, as well as enabling these engines an opportunity to compete as a new generation of vehicles is developed that are far more efficient than today's vehicles (White House Press Release, July 23, 1997). It is always possible, of course, that some new technological problems could emerge that could impact diesel engine availability—e.g., confirmation that some of the newer engines produce high levels of ''nanoparticles'' particulates and that such emissions pose some sort of a health problem. Research of nanoparticles and their health effects is currently a topic of investigation (Bagley et al., 1996).

A related question has been whether the costs of the ''high-tech'' diesel engines will make them unaffordable in practice to the mining community.

MSHA believes the new engines will be affordable. The fact that the engine industry has agreed to the new standards, and has some assurance of what the applicable standards will be for the foreseeable future, should help keep costs in check.

In theory, underground mines can control costs by purchasing certain types of new engines that do not have to meet the new EPA standards. The rules on heavy duty on-highway truck engines were not applied to engines intended to be used in underground coal mines (59 FR 31336), and the new proposed rules on nonroad vehicles would likewise not be mandatory for engines intended for any underground mining use. In practice, however, it is not likely that engine manufacturers will produce special engines once they switch over their production lines to meet the new EPA standards, because there are few types and sizes of engines in production for which the mining community is the major market. Moreover, the larger engines (above 750 hp) are specifically covered by the EPA nonroad rules (*Engine Manufacturers Assn.* v. *EPA*, 88 F.3d 1075, 319 U.S. App.D.C. 12 (1996).

MSHA Approved Engines. Acting under its own authority to protect miner safety and health, MSHA requires that diesel engines used in certain types of mining operations be ''approved'' as meeting certain tailpipe standards.

In some ways, the standards are akin to those of EPA and CARB. For example, MSHA, CARB and EPA generally use the same tests to check emissions. MSHA uses a steady state, 8-mode test cycle, the same as EPA and CARB use to test engines designed for use in off-road equipment; however, EPA uses a different, transient test for on-highway engines.

But to be approved by MSHA, an engine does not have to be as clean as the newer diesel engines, every generation of which must meet ever tighter EPA and CARB tailpipe standards. Approval of an engine by MSHA merely ensures that the tailpipe emissions from that engine meet certain basic standards of cleanliness—cleaner than the engines which many mines continue to use.

The MSHA approval rules were revised in 1996 (as part of the 1996 rule on the use of diesel equipment in underground coal mines) to provide the mining community with additional information about the cleanliness of the emissions emerging from the tailpipe of various engines. Specifically, the agency now requires that a particulate index (PI) be reported as part of MSHA's engine approval. This index permits operators to evaluate the contribution of a proposed new addition to the fleet to the mine's particulate concentrations.

There is no requirement that approved engines meet a particular PI; rather, the requirement is for information purposes only. In its 1996 rulemaking addressing diesel equipment in underground coal mines, MSHA explicitly deferred until this rulemaking the question of whether to require engines used in mining environments to meet a particular PI (61 FR 55420–21, 55437). The Agency has decided not to take that approach, for the reasons discussed in Part V of this preamble.

(5) *Limiting the Public's Exposure to Soot—Ambient Air Quality Standards.* Pursuant to the Clean Air Act, EPA is responsible for setting air pollution standards to protect the public from toxic air contaminants. These include standards to limit exposure to particulate matter. The pressures to comply with these limits have an impact upon the mining industry, which contributes various types of particulate matter into the environment during mining operations, and a special impact on the coal mining industry whose product is used extensively in emission-generating power facilities. But those standards hold interest for the mining community in other ways as well, for underlying some of them is a large body of evidence on the harmful effects of airborne particulate matter on human health. Increasingly, that evidence has pointed toward the risks of the smallest particulates—including the particles generated by diesel engines.

This section provides an overview of EPA rulemaking on particulate matter. For more detailed information, commenters are referred to ''The Plain English Guide to the Clean Air Act,'' EPA 400–K–93–001, 1993, to the ''Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information'', EPA–452/R–96–013, 1996; and, on the latest rule, to EPA Fact Sheets, July 17, 1997. These and other documents are available from EPA's Web site.

Background. Air quality standards involve a two-step process: standard setting by EPA, and implementation by each State.

Under the law, EPA is specifically responsible for reviewing the scientific literature concerning air pollutants, and establishing and revising National Ambient Air Quality Standards (NAAQS) to minimize the risks to health and the environment associated with such pollutants. It is supposed to do a review every five years. Feasibility of compliance by pollution sources is not supposed to be a factor in establishing NAAQS. Rather, EPA is required to set the level that provides ''an adequate margin of safety'' in protecting the health of the public.

Implementation of each national standard is the responsibility of the states. Each must develop a state implementation plan that ensures air quality in the state consistent with the ambient air quality standard. Thus, each state has a great deal of flexibility in targeting particular modes of emission (e.g., mobile or stationary, specific industry or all, public sources of emissions vs. private-sector sources), and in what requirements to impose on polluters. However, EPA must approve the state plans pursuant to criteria it establishes, and then take pollution measurements to determine whether all counties within the state are meeting each ambient air quality standard. An area not meeting an NAAQS is known as a ''nonattainment area''.

TSP. Particulate matter originates from all types of stationary, mobile and natural sources, and can also be created from the transformation of a variety of gaseous emissions from such sources. In the context of a global atmosphere, all these particles are mixed together, and both people and the environment are exposed to a ''particulate soup'' the chemical and physical properties of which vary greatly with time, region, meteorology, and source category. The first ambient air quality standards dealing with particulate matter did not distinguish among these particles. Rather, the EPA established a single NAAQS for ''total suspended particulates'', known as ''TSP.'' Under this approach, the states could come into compliance with the ambient air requirement by controlling any type or size of TSP. As long as the total TSP was under the NAAQS—which was established based on the science available in the 1970s—the state met the requirement.

PM_{10}. When the EPA completed a new review of the scientific evidence in the mid-eighties, its conclusions led it to revise the particulate NAAQS to focus more narrowly on those particulates less than 10 microns in diameter, or PM_{10}. The standard issued in 1987 contained two components: an annual average limit of 150 $\mu g/m^3$, and a 24-hour limit of 50 $\mu g/m^3$. This new standard required the states to reevaluate their situations and, if they had areas that exceeded the new PM_{10} limit, to refocus their compliance plans on reducing those particulates smaller than 10 microns in size. Sources of PM_{10} include power plants, iron and steel production, chemical and wood products

manufacturing, wind-blown and roadway fugitive dust, secondary aerosols and many natural sources.

Some state implementation plans required surface mines to take actions to help the state meet the PM_{10} standard. In particular, some surface mines in Western states were required to control the coarser particles—e.g., by spraying water on roadways to limit dust. The mining industry has objected to such controls, arguing that the coarser particles do not adversely impact health, and has sought to have them excluded from the EPA ambient air standards (Shea, 1995; comments of Newmont Gold Company, March 11, 1997, EPA docket number A–95–54, IV–D–2346).

$PM_{2.5}$. The next scientific review was completed in 1996, following suit by the American Lung Association and others. A proposed rule was published in November of 1996, and, after public hearings and review by the Office of the President, a final rule was promulgated on July 18, 1997 (62 FR 38651).

The new rule further modifies the standard for particulate matter. Under the new rule, the existing national ambient air quality standard for PM_{10} remains basically the same—an annual average limit of 150 $\mu g/m^3$ (with some adjustment as to how this is measured for compliance purposes), and a 24-hour ceiling of 50 $\mu g/m^3$. In addition, however, a new NAAQS has now been established for ''fine particulate matter'' that is less than 2.5 microns in size. The $PM_{2.5}$ annual limit is set at 15 $\mu g/m^3$, with a 24-hour ceiling of 65 $\mu g/m^3$.

The basis for the $PM_{2.5}$ NAAQS is a new body of scientific data suggesting that particles in this size range are the ones responsible for the most serious health effects associated with particulate matter. The evidence was thoroughly reviewed by a number of scientific panels through an extended process. (A chart of the scientific review process is available on EPA's web site—http://ttnwww.rtpnc.epa.gov/naaqspro/pmnaaqs.gif). The proposed rule resulted in considerable press attention, and hearings by Congress, in which this scientific evidence was further discussed. Following a careful review, President Clinton announced his concurrence with the rulemaking in light of the scientific evidence of risk. However, the implementation schedule for the rule is long enough so that the next review of the science is scheduled to be completed before the states are required to meet the new NAAQS for $PM_{2.5}$—hence, adjustment of the standard is still possible before implementation.

Implications for the Mining Community. As noted earlier in this part, diesel particulate matter is mostly less than 1.0 micron in size. It is, therefore, a fine particulate. The body of evidence of human health risk from environmental exposure to fine particulates must, therefore, be considered in assessing the risk of harm to miners of occupational exposure to one type of fine particulate—diesel particulate. MSHA has accordingly done so in its risk assessment (see Part III of this preamble).

(6) *Controlling Diesel Particulate Emissions in Mining—a Toolbox.* Efforts to control diesel particulate emissions have been under review for some time within the mining community, and accordingly, there is considerable practical information available about controls—both in general terms, and with respect to specific mining situations.

Workshops. In 1995, MSHA sponsored three workshops ''to bring together in a forum format the U.S. organizations who have a stake in limiting the exposure of miners to diesel particulate (including) mine operators, labor unions, trade organizations, engine manufacturers, fuel producers, exhaust aftertreatment manufacturers, and academia.'' (McAteer, 1995). The sessions provided an overview of the literature and of diesel particulate exposures in the mining industry, state-of-the-art technologies available for reducing diesel particulate levels, presentations on engineering technologies toward that end, and identification of possible strategies whereby miners' exposure to diesel particulate matter can be limited both practically and effectively. One workshop was held in Beckley, West Virginia on September 12 and 13, and the other two were held on October 6, and October 12 and 13, 1995, in Mt Vernon, Illinois and Salt Lake City, Utah, respectively. A transcript was made. During a speech early the next year, the Deputy Assistant Secretary for MSHA characterized what took place at these workshops:

> The biggest debate at the workshops was whether or not diesel exhaust causes lung cancer and whether MSHA should move to regulate exposures. Despite this debate, what emerged at the workshops was a general recognition and agreement that a health problem seems to exist with the current high levels of diesel exhaust exposure in the mines. One could observe that while all the debate about the studies and the level of risk was going on, something else interesting was happening at the workshops: one by one miners, mining companies, and manufacturers began describing efforts already underway to reduce exposures. Many are actively trying to solve what they clearly recognize is a problem. Some mine operators had switched to low sulfur fuel that reduces particulate levels. Some had increased mine ventilation. One company had tried a soy-based fuel and found it lowered particulate levels. Several were instituting better maintenance techniques for equipment. Another had hired extra diesel mechanics. Several companies had purchased electronically controlled, cleaner, engines. Another was testing a prototype of a new filter system. Yet another was using disposable diesel exhaust filters. These were not all flawless attempts, nor were they all inexpensive. But one presenter after another described examples of serious efforts currently underway to reduce diesel emissions. (Hricko, 1996).

Toolbox. In March of 1997, MSHA issued, in draft form, a publication entitled ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox''. The draft publication was disseminated by MSHA to all underground mines known to use diesel equipment and posted on MSHA's Web site. Following comment, the Toolbox was finalized in the Fall of 1997 and disseminated. For the convenience of the mining community, a copy is appended to the end of this document.

The material on controls is organized as a ''Toolbox'' so that mine operators have the option of choosing the control technology that is most applicable to their mining operation for reducing exposures to dpm. The Toolbox provides information about nine types of controls that can reduce dpm emissions or exposures: low emission engines; fuels; aftertreatment devices; ventilation; enclosed cabs; engine maintenance; work practices and training; fleet management; and respiratory protective equipment.

The Estimator. MSHA has developed a model that can help mine operators evaluate the effect of alternative controls on dpm concentrations. The model is in the form of a template that can be used on standard computer spreadsheet programs; as information about a new combination of controls is entered, the results are promptly displayed. A complete description of this model, referred to as ''the Estimator,'' and several examples, are presented in Part V of this preamble. MSHA intends to make this model widely available to the mining community, and hopes to receive comments in connection with this rulemaking based on the results of estimates conducted with this model.

History of diesel aftertreatment devices in mining. For many years, the majority of the experience has been with the use of oxidation catalytic converters (OCCs), but in more recent years both ceramic and paper filtration systems have also been used more widely.

OCCs began to be used in underground mines in the 1960's to control carbon monoxide, hydrocarbons and odor (Haney, Saseen, Waytulonis, 1997). That use has been widespread. It has been estimated that more than 10,000 OCCs have been put into the mining industry over the years (McKinnon, dpm Workshop, Beckley, WV, 1995).

When such catalysts are used in conjunction with low sulfur fuel, there is a reduction of up to 90 percent of carbon monoxide, hydrocarbons and aldehyde emissions, and nitric oxide can be transformed to nitrogen dioxide. Moreover, there is also an approximately 20 percent reduction in diesel particulate mass. The diesel particulate reduction comes from the elimination of the soluble organic compounds that, when condensed through the cooling phase in the exhaust, will attach to the elemental carbon cores of diesel particulate. Unfortunately, this effect is lost if the fuel contains more than 0.05 percent sulfur. In such cases, sulfates can be produced which ''poison'' the catalyst, severely reducing its life. With the use of low sulfur fuel, some engine manufacturers have certified diesel engines with catalytic converter systems to meet EPA requirements for lower particulate levels (see Section 4 of this part).

The particulate trapping capabilities of some OCCs are even higher. In 1995, the EPA implemented standards requiring older buses in urban areas to reduce the dpm emissions from rebuilt bus engines (40 CFR 85.1403). Aftertreatment manufacturers developed catalytic converter systems capable of reducing dpm by 25%. Such systems are available for larger diesel engines common in the underground metal and nonmetal sector.

Other types of aftertreatment devices capable of more significant reductions in particulate levels began to be developed for commercial applications following EPA rules in 1985 limiting diesel particulate emissions from heavy duty diesel engines. The wall flow type ceramic honeycomb diesel particulate filter system was initially the most promising approach (SAE, SP–735, 1988). However, due to the extensive work performed by the engine manufacturers on new technological designs of the diesel engine's combustion system, and the use of low sulfur fuel, particulate traps turned out to be unnecessary to comply with the EPA standards of the time.

While this work was underway, efforts were also being made to transfer this aftertreatment technology to the mining industry. The former Bureau of Mines investigated the use of catalyzed diesel particulate filters in underground mines in the United States (BOM, RI–9478, 1993). The investigation demonstrated that filters could work, but that there were problems associated with their use on individual unit installations, and the Bureau made recommendations for installation of ceramic filters on mining vehicles. But as noted by one commenter at one of the MSHA workshops in 1995, ''while ceramic filters give good results early in their life cycle, they have a relatively short life, are very expensive and unreliable.'' (Ellington, dpm Workshop, Salt Lake City, UT, 1995).

Canadian mines also began to experiment with ceramic traps in the 1980's with similar results (BOM, IC 9324, 1992). Work in Canada today continues under the auspices of the Diesel Emission Evaluation Program (DEEP), established by the Canadian Centre for Mineral and Energy Technology in 1996 (DEEP Plenary Proceedings, November 1996). The goals of DEEP are to: (1) evaluate aerosol sampling and analytical methods for dpm; and (2) evaluate the in-mine performance and costs of various diesel exhaust control strategies.

Work with ceramic filters in the last few years has led to the development of the ceramic fiber wound filter cartridge (SAE, SP–1073, 1995). The ceramic fiber has been reported by the manufacturer to have dpm reduction efficiencies up to 80 percent. This system has been used on vehicles to comply with German requirements that all diesel engines used in confined areas be filtered. Other manufacturers have made the wall flow type ceramic honeycomb dpm filter system commercially available to meet the German standard. In the case of some engines, a choice of the two types is available; but depending upon horsepower, this may not always be the case.

In the early 1990's, MSHA worked with the former Bureau of Mines and a filter manufacturer to successfully develop and test a pleated paper filter for wet water scrubber systems of permissible diesel powered equipment. The dpm reduction from these filters has been determined in the field by the former BOM to be up to 95% (BOM, IC 9324). The same type of filter has been used in recently developed dry systems for permissible machines, with reported laboratory reductions in dpm of 98% (Paas, dpm Workshop, Beckley WV, 1995).

ANPRM Comments. The ANPRM requested information about several kinds of work practices that might be useful in reducing dpm concentrations. These comments were provided well before the workshops mentioned above, and before MSHA issued its diesel equipment standard for underground coal mines, and are thus somewhat dated. But, solely to illustrate the range of comments received, the following sections review the comments concerning certain work practices—fuel type, fuel additives, and maintenance practices.

Type of Diesel Fuel Required. It has been well established that the quality of diesel fuel influences emissions. Sulfur content, cetane number, aromatic content, density, viscosity, and volatility are interrelated fuel properties which can influence emissions. Sulfur content can have a significant effect on diesel emissions.

Use of low sulfur diesel fuel reduces the sulfate fraction of dpm matter emissions, reduces objectionable odors associated with diesel exhaust and allows oxidation catalysts to perform properly. The use of low sulfur fuel also reduces engine wear and maintenance costs. Fuel sulfur content is a particularly important parameter when the fuel is used in low emission diesel engines. Low sulfur diesel fuel is available nationwide due to EPA regulations (40 CFR Parts 80 and 86). In MSHA's ANPRM, information was requested on what reduction in concentration of diesel particulate can be achieved through the use of low sulfur fuel. Information was also solicited as to whether the use of low sulfur fuel reduces the hazard associated with diesel emissions.

Responses from commenters stated that there would be a positive reduction in particulate with the use of low sulfur fuel. One commenter stated that the brake specific exhaust emissions (grams/brake horsepower-hour) of particulate would decrease by about 0.06 g/bhp-hr for a fuel sulfur reduction of 0.25 weight percent sulfur. The particulate reduction effect is proportional to the change in sulfur content. Another commenter stated that a typical No. 2 diesel fuel containing 0.25 percent weight sulfur will include 1 to 1.6 grams of sulfate particulate per gallon of fuel consumed. A fuel containing 0.05 percent weight sulfur will reduce sulfate particulate to 0.2–0.3 grams per gallon of fuel consumed, an 80 percent reduction.

In responding to the question on whether reducing the sulfur content of the fuel will reduce the health hazard associated with diesel emissions, several commenters stated that they knew of no evidence that sulfur reduction reduces the hazard of the particulate. MSHA also is not aware of any data supporting the proposition that reducing the sulfur content of the fuel will reduce the health hazard associated with diesel emissions. However, in the preamble to the final rule for the EPA requirement for the use of low sulfur fuel, EPA stated that there were a number of benefits which could be attributed to lowering the sulfur content of diesel fuel. The first area was in exhaust aftertreatment technology. Reductions in fuel sulfur content will result in small reductions in sulfur compounds being emitted. This will cause the whole particulate concentration from the engine to be reduced. However, the number of carbon particles are is not reduced, therefore, the total carbon concentration would be the same.

The major benefit of using low sulfur fuel is that the reduction of sulfur allows for the use of some aftertreatment devices such as catalytic converters, and catalyzed particulate traps which were prohibited with fuels of high sulfur content (greater than 0.05 percent sulfur). The high sulfur content led to sulfate particulate that when passed through the catalytic converter or catalyzed traps was changed to sulfuric acid when the sulfates came in contact with water vapor. Using low sulfur fuel permits these devices to be used.

The second area of benefits that the EPA noted was that of reduced engine wear with the use of low sulfur fuel. Reducing engine wear will help maintain engines in their near manufactured condition that would help limit increases in particulate matter due to lack of maintenance or age of the engine.

Other questions posed in the ANPRM requested information concerning the differences in No. 1 and No. 2 diesel fuel regarding particulate formation; the current sulfur content of diesel fuel used in mines; and when would 0.05 percent sulfur fuel be available to the mining industry.

In response to those questions, commenters stated that a difference in No. 1 and No. 2 fuel regarding particulate formation would be that No. 1 fuel typically has less sulfur than No. 2 fuel and would therefore be expected to produce less particulate. Also, the No. 1 fuel has a lower density, boiling range and aromatic content and a higher cetane number. All of these fuel property differences tend to cause lower particulate emissions.

Commenters also stated that the sulfur content of fuels commercially available for diesel-powered equipment can vary from nearly zero to 1 percent. The national average sulfur content for commercial No. 2 diesel fuel is approximately 0.25 percent. One commenter stated that sulfur content varied from region to region and the National Institute of Petroleum and Energy Research survey could be used to get the answers for specific regions.

Commenters noted that low sulfur fuel, less than 0.05 percent sulfur, would be available for on-highway use as mandated by the EPA by October 1993. Also, California requires the statewide availability of 0.05 percent sulfur fuel for all diesel engine applications by the same date. Although the EPA mandate ensures that low sulfur fuel will be available throughout the nation, commenters indicated the availability for off-road and mining application was uncertain at that time.

The ANPRM also requested information on the differences in the per gallon costs among No. 1, No. 2 and 0.05 percent sulfur fuel; how much fuel is used annually in the mining industry; and what would be the economic impact on mining of using 0.05 percent sulfur fuel. In response, commenters stated that No. 1 fuel typically costs the user 10 to 20 percent more than does No. 2 fuel. They also stated that the price of 0.05 percent sulfur fuel will eventually be set by the competitive market conditions. No information was submitted for accurately estimating fuel usage costs to the industry. The economic impact on the mining industry of using 0.05 percent fuel will vary greatly from mine to mine. Factors influencing that cost are a mine's dependence on diesel powered equipment, the location of the mine and existing regulation. Mines relying heavily on diesel equipment will be most impacted.

Another commenter stated that the price for 0.05 percent fuel is forecast to average about 2 cents per gallon higher than the price for typical current No. 2 fuel. Kerosene and No. 1 distillate are forecast as 2 to 4 cents per gallon above 0.05 percent fuel and 4 to 6 cents above current No. 2 fuel. A recent census of mining and manufacturing dated 1987 showed mining industry energy consumption from all sources to total 1968.4 trillion BTU per year. Coal mining alone used 9.96 million barrels annually of distillate, at a cost of 258.1 million dollars. Included in these quantities was diesel fuel for surface equipment and vehicles at or around the mine site. The commenter also stated that applying a cost increase of 2 cents per gallon to the total industry distillate consumption would increase annual fuel costs by $24.3 million. For coal mining only, the cost increase would be $8.4 million annually.

While MSHA does not have an opinion on the accuracy of the information received in this regard, it is in any event dated. Since the time that the ANPRM was open, the availability of low sulfur fuel has become more common. Comments received at MSHA's Diesel Workshops indicate that low sulfur fuel is readily available and that all that is needed to obtain it is to specify the desired fuel quality on the purchase order. The differences in the fuel properties of No. 1 and No. 2 fuel are consistent with specifications provided by ASTM and other literature information concerning fuel properties.

Fuel Additives. Information relative to fuel additives was requested in MSHA's ANPRM. The ANPRM requested information on the availability of fuel additives that can reduce dpm or additives being developed; what diesel emissions reduction can be expected through the use of these fuel additives; the cost of additives and advantages to their use; and will these fuel additives introduce other health hazards. One commenter stated that cetane improvers and detergent additives can reduce dpm from 0 to 10 percent. The data, however, does not indicate consistent benefits as in the case with sulfur reduction. Oxygenate additives can give larger benefits, as with methanol, but then the oxygenate is not so much an additive as a fuel blend. Another commenter stated the cost depended on the price and concentration of the additive. This commenter estimated the cost to be between three and seven cents per gallon of fuel.

Another commenter stated that some additives are used for reducing injector tip fouling, other alternative additives also are offered specifically for the purpose of reducing smoke or dpm such as organometallic compounds, i.e., copper, barium, calcium, iron or platinum; oxygenate supplements containing alcohols or peroxides; and other proprietary hydrocarbons. The commenter did not quantify the expected reductions in dpm.

The former Bureau of Mines commented on an investigation of barium-based, manganese based, and ferrocene fuel additives. Details of the investigation are found in the literature (BOM, IC 9238, 1990). In general, fuel additives are not widely used by the mining industry to reduce dpm or to reduce regeneration temperatures in ceramic particulate filters. Research has shown aerosol reductions of about 30 percent without significant adverse impacts although new pollutants derived from the fuel additive remain a question.

One commenter stated that a cetane improver and detergent additives should not exceed 1 cent per gallon at the treat rates likely to be used. The use of oxygenates depends on which one and how much but would be perhaps an order of magnitude higher than the use of a cetane improver. One commenter also added that any fuel economy advantages would be very small.

In response to the creation of a health hazard when using additives, one commenter stated that excessive exposure to cetane improver (alkyl nitrates), which is hazardous to humans, requires special handling because of poor thermal stability. Detergent additives are similar to those used in gasoline and probably have similar safety and health issues. Except at low load operation, additives are not likely to result in any significant quantity in the exhaust. Another commenter stated that the effect on human health of new chemical exhaust species that may result from the use of some of these additives has not been determined. Engine manufacturers also are concerned about the use of such products because their effectiveness has not always been adequately demonstrated and, in many cases, the effect on engine durability has not been well-documented for different designs and operating conditions.

MSHA agrees with the commenters that fuel additives can affect engine performance and exhaust emissions. MSHA's experience with additives has shown that they can enhance fuel quality by increasing the cetane number, depressing the cloud point, or in the case of a barium based additive, affect the combustion process resulting in a reduction of particulate output. MSHA's experience also has shown that in most cases the effects of an additive on engine performance or emissions cannot be adequately determined without extensive research. The additives listed on EPA's list of ''registered additives'' meet the requirements of EPA's standards in 40 CFR Part 79.

MSHA is concerned about the use of untested fuel additives. A large number of additives are currently being marketed to reduce emissions. These additives include cetane improvers that increase the cetane number of the fuel, which may reduce emissions and improve starting; detergents that are used primarily to keep the fuel injectors clean; dispersants or surfactants that prevent the formation of thicker compounds that can form deposits on the fuel injectors or plug filters. While the use of many of these additives will result in reduced particulate emission, some have been found to introduce harmful agents into the environment. For this reason, it is a good idea to limit the use of additives to those that have been registered by the EPA.

Maintenance Practices. The ANPRM requested information concerning what maintenance procedures are effective in reducing diesel particulate emissions from existing diesel-powered equipment, and what additional maintenance procedures would be required in conjunction with anticipated developments of new diesel particulate reduction technology. Information was also requested about the amount of time to perform the maintenance procedures and if any, loss of production time.

Commenters stated that some maintenance procedures have a very dramatic impact on particulate emissions, while other procedures that are equally important for other reasons have little or no impact at all on particulates. Another commenter stated that maintenance procedures are intended to ensure that the engine operates and will continue to operate as intended. Such procedures will not reduce diesel particulate below that of the new, original equipment. A commenter stated that the diesel engine industry experience has demonstrated that emissions deterioration over the useful life of an engine is minimal.

Commenters stated that depending on the implied technology, the need for additional maintenance will be based on complexity of the control devices. Also, time for maintenance will be dependent on complexity of the control device. Some production loss will occur due to increased maintenance procedures.

MSHA agrees with the commenters' view that maintenance does affect engine emissions, some more dramatically than others. Research has clearly shown that without engine maintenance, all engine emissions will increase greatly. For example, the former Bureau of Mines, in conjunction with Southwest Research, conducted extensive research on the effects of maintenance on diesel engines which indicated this result (BOM contract H–0292009, 1979). MSHA agrees that emissions increase is minimal over the useful life of the engine only when proper maintenance is performed daily. However, MSHA believes that with the awareness of the increased maintenance, production may not be lost due to the increased time that the machines are able to operate without unwanted down time due to poor maintenance practices.

MSHA's diesel ''Toolbox'' includes an extensive discussion on the importance of maintenance. It reminds operators and diesel maintenance personnel of the basic systems on diesel engines that need to be maintained, and how to avoid various problems. It includes suggestions from others in the mining community, and information on their success or difficulties in this regard.

(7) *Existing Mining Standards that Limit Miner Exposure to Occupational Diesel Particulate Emissions.* MSHA already has in place various requirements that help to control miner exposure to diesel emissions in underground mines—including exposure to diesel particulate. These include ventilation requirements, engine approval requirements, and explicit restrictions on the concentration of various gases in the mine environment.

In addition, in 1996, MSHA promulgated a rule governing the use of diesel-powered equipment in underground coal mines (61 FR 55412). While the primary focus of the rulemaking was to promote the safe use of diesel engines in the hazardous environment of underground coal mines, various parts of the rule will help to control exposure to harmful diesel emissions in those mines. The new rule revised and updated MSHA's diesel engine approval requirements and the ventilation requirements for underground coal mines using diesel equipment, and established requirements concerning diesel fuel sulfur content and the idling, maintenance and emissions testing of diesel engines in underground coal mines.

Background. Beginning in the 1940s, mining regulations were promulgated to promote the safe and healthful use of diesel engines in underground mines. In 1944, Part 31 established procedures for limiting the gaseous emissions and establishing the recommended dilution air quantity for mine locomotives that use diesel fuel. In 1949, Part 32 established procedures for testing of mobile diesel-powered equipment for non-coal mines. In 1961, Part 36 was added to provide requirements for the use of diesel equipment in gassy noncoal mines, in which engines must be temperature controlled to prevent explosive hazards. These rules responded to research conducted by the former Bureau of Mines.

Continued research by the former Bureau of Mines in the 1950s and 1960s led to refinements of its ventilation recommendations, particularly when multiple engines are in use. An airflow of 100 to 250 cfm/bhp was recommended for engines that have a properly adjusted fuel to air ratio (Holtz, 1960). An additive ventilation requirement was recommended for operation of multiple diesel units, which could be relaxed based on the mine operating procedures. This approach was subsequently refined to become a 100–75–50 percent guideline (MSHA Policy Memorandum 81–19MM, 1981). Under this guideline, when multiple pieces of diesel equipment are operated, the required airflow on a split of air would be the sum of: (a) 100 percent of the nameplate quantity for the vehicle with the highest nameplate air quantity requirement; (b) 75 percent of the nameplate air quantity requirement of the vehicle with the next highest nameplate air quantity requirement; and (c) 50 percent of the nameplate airflow for each additional piece of diesel equipment.

Diesel Equipment Rule. On October 6, 1987, MSHA published in the **Federal Register** (52 FR 37381) a notice establishing a committee to advise the Secretary of Labor on health and safety standards related to the use of diesel-powered equipment in underground coal mines. The ''Mine Safety and Health Advisory Committee on Standards and Regulations for Diesel-Powered Equipment in Underground Coal Mines'' (the Advisory Committee) addressed three areas of concern: the approval of diesel-powered equipment, the safe use of diesel equipment in underground coal mines, and the protection of miners' health. The Advisory Committee submitted its recommendations in July 1988.

With respect to the approval of diesel-powered equipment, the Advisory Committee recommended that all diesel equipment except for a limited class, be approved for use in underground coal mines. This approval would involve both safety (e.g., fire suppression systems) and health factors (e.g., maximum exhaust emissions).

With respect to the safe use of diesel equipment in underground coal mines, the Advisory Committee recommended that standards be developed to address the safety aspects of the use of diesel equipment, including such concerns as equipment maintenance, training of mechanics, and the storage and transport of diesel fuel.

The Advisory Committee also made recommendations concerning miner health, discussed later in this section.

As a result of the Advisory Committee's recommendations on approval and safe use, MSHA developed and, on October 25, 1996, promulgated as a final rule, standards for the ''Approval, Exhaust Gas Monitoring, and Safety Requirements for the Use of Diesel-Powered Equipment in Underground Coal Mines'' (61 FR 55412).

The October 25, 1996 final rule on diesels focuses on the safe use of diesels in underground coal mines. Integrated requirements are established for the safe storage, handling, and transport of diesel fuel underground, training of mine personnel, minimum ventilating air quantities for diesel powered equipment, maintenance requirements, fire suppression, and design features for nonpermissible machines. While the focus was on safety, certain rules related to emissions are included in the final rule. For example, the final rule requires maintenance on diesel powered equipment. Regular maintenance on diesel powered equipment should keep the diesel engine and vehicle operation at its original or baseline condition. However, as a check that the maintenance is being performed, MSHA wrote a standard for checking the gaseous CO emission levels on permissible and heavy duty outby machines to determine the need for maintenance. The CO check requires that a regular repeatable loaded engine condition be run on a weekly basis and the CO measured. Carbon monoxide is a good indicator of engine condition. If the CO measurement increases to a higher concentration than what was normally measured during the past weekly checks, then a maintenance person would know that either the regular maintenance was missed or a problem has developed that is more significant than could be identified by a general daily maintenance program.

Consistent with the Advisory Committee's recommendation, the final rule, among other things, requires that virtually all diesel-powered engines used in underground coal mines be approved by MSHA (30 CFR Part 7 (approval requirements), Part 36 (permissible machines defined), and Part 75 (use of such equipment in underground coal mines). The approval requirements, among other things, are designed to require clean-burning engines in diesel-powered equipment (61 FR 55417). In promulgating the final rule, MSHA recognized that clean-burning engines are ''critically important'' to reducing toxic gasses to levels that can be controlled through ventilation. (Id.). To achieve the objective of clean-burning engines, the rule sets performance standards which must be met for virtually all diesel-powered equipment in underground coal mines (30 CFR Part 7).

Consistent with the recommendation of the Advisory Committee, the technical requirements for approved diesel engines include undiluted exhaust limits for carbon monoxide and oxides of nitrogen (61 FR 55419). As recommended by the Advisory Committee, the limits for these gasses are derived from existing 30 CFR Part 36 (61 FR 55419). Also, consistent with the recommendation of the Advisory Committee, the final rule requires that as part of the approval process, ventilating air quantities necessary to maintain the gaseous emissions of diesel engines within existing required ambient limits be set (61 FR 55420). As recommended by the Advisory Committee, the ventilating air quantities are required to appear on the engine's approval plate (61 FR 55421).

The final rule also implements the Advisory Committee's recommendation that a particulate index be set for diesel engines (61 FR 55421). Although, as discussed below, there is not yet a specific standard limiting miners' exposure to diesel particulate, the particulate index is nonetheless useful in providing information to the mining community so that operators can compare the particulate levels generated by different engines (61 FR 55421).

Also consistent with the recommendation of the Advisory Committee, the final rule addresses the monitoring and control of gaseous diesel exhaust emissions (30 CFR part 70; 61 FR 55413). In this regard, the final rule requires that mine operators take samples of carbon monoxide and nitrogen dioxide (61 FR 55413, 55430–55431). Samples exceeding an action level of 50 percent of the threshold limits set forth in 30 CFR 75.322, trigger corrective action by the mine operator (30 CFR part 70, 61 FR 55413). Also consistent with the Advisory Committee's recommendation, the final rule requires that diesel-powered equipment be adequately maintained (30 CFR 75.1914; 61 FR 55414). Among other things, as recommended by the Advisory Committee, the rule requires the weekly examination of diesel-powered equipment, including testing of undiluted exhaust emissions for certain types of equipment (30 CFR 75.1914(g)). In addition, consistent with the Advisory Committee's recommendation, operators are required to establish programs to ensure that those performing maintenance on diesel equipment are qualified (61 FR 55414). As explained in the preamble, maintenance requirements were included because of MSHA's recognition that inadequate equipment maintenance can, among other things, result in increased levels of harmful gaseous and particulate components from diesel exhaust (61 FR 55413–55414).

Consistent with the Advisory Committee's recommendation, the final rule also requires that underground coal mine operators use low sulfur diesel fuel (30 CFR 75.1901; 61 FR 55413). The use of low sulfur fuel lowers not only the amount of gaseous emissions, but also the amount of diesel particulate emissions. (Id.). To further reduce miners' exposure to diesel exhaust, the final rule prohibits operators from unnecessarily idling diesel-powered equipment (30 CFR 75.1916(d)).

Also consistent with the recommendation of the Advisory Committee, the final rule establishes minimum air quantity requirements in areas of underground coal mines where diesel-powered equipment is operated (30 CFR 75.325). As set forth in the preamble, MSHA believes that effective mine ventilation is a key component in the control of miners' exposure to gasses and particulate emissions generated by diesel equipment (61 FR 55433). The final rule also requires generally that mine operators maintain the approval plate quantity minimum airflow in areas of underground coal mines where diesel-powered equipment is operated (30 CFR 75.325 [3]).

The diesel equipment rule will help the mining community use diesel-powered equipment more safely in underground coal mines. As discussed throughout this preamble, the diesel equipment rule has many features which, though it was not their primary purpose, will incidently reduce harmful diesel emissions in underground coal mines—including the particulate component of these emissions. (The requirements of the diesel equipment rule are highlighted with a special typeface in MSHA's publication, ''Practical Ways to Control Exposure to Diesel Exhaust in Mining—a Toolbox''). An example is the requirement in the diesel equipment rule that all engines used in underground coal mines be approved engines, and be maintained in approved condition—thus reducing emissions at the source.

In developing this safety rule, however, MSHA did not explicitly consider the risks to miners of a working lifetime of dpm exposure at very high levels, nor the actions that could be taken to specifically reduce those exposure levels in underground coal mines. Moreover, the rule does not apply to the remainder of the mining industry, where the use of diesel machinery is much more intense than in underground coal.

Gas limits. Various organizations have established or recommended limits for many of the gasses occurring in diesel exhaust. Some of these are listed in Table II–2, together with information about the limits currently enforced by MSHA. MSHA requires mine operators to comply with gas specific threshold limit values (TLV(TM)s) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1972 (for coal mines) and in 1973 (for metal and nonmetal mines).

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[3] On December 23, 1997, the National Mining Association and Energy West Mining Company filed petitions for review of the final rule. *National Mining Association* v. *Secretary of Labor,* Nos. 96–1489 and 96–1490. These cases were consolidated and held in abeyance pending discussions between the mining industry and the Secretary. On March 19, 1998, petitioners filed an Unopposed Joint Motion for Voluntary Dismissal. In April 1998, the Court granted the Motion for Dismissal.

TABLE II-2 GASEOUS EXPOSURE LIMITS (PPM)

Pollutant	Range of Limits Recommended		MSHA Limits	
			$Coal_A$	M/NM_B
HCHO	0.016_C	0.3_D	2	2
CO	25_D	50	50	50
CO_2	$5{,}000_C$	5,000	5,000	5,000
NO	$25_{C,D,E}$	25	25	25
NO_2	1_F	3_D	5	5
SO_2	$2_{C,D}$	5_E	2	5

Table Notes:
A) ACGIH, 1972
B) ACGIH, 1973
C) NIOSH recommended exposure limit (REL), based on a 10-hour, time-weighted average
D) ACGIH, 1996
E) OSHA permissible exposure limit (PEL)
F) NIOSH recommends only a 1-ppm, 15-minutes, short-term exposure limit (STEL)

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In 1989, MSHA proposed changing some of these limits in the context of a proposed rule on air quality standards (54 FR 35760). Following opportunity for comment and hearings, a portion of that proposed rule, concerning control of drill dust, has been promulgated, but the other components are still under review. To change a limit at this point in time requires a regulatory action; the rule does not provide for their automatic updating.

(8) How Other Jurisdictions Are Restricting Occupational Exposure to Diesel Soot.

On April 9, 1998, MSHA published a proposed rule to limit the exposure of underground coal miners to dpm. With this proposed rule, MSHA's rulemaking is the first effort by the Federal government to deal with the special risks faced by workers exposed to diesel exhaust on the job—because, as described in detail in the Part III of this preamble, miner exposures are an order of magnitude above those of any other group of workers. But others have been looking at the problem of exposure to diesel soot.

MSHA's Final Rule for Underground Coal Mines. In 1996, MSHA published a final rule on addressing the safe use of diesels in underground coal mines. Integrated requirements are established for the safe storage, handling, and transport of diesel fuel underground, training of mine personnel, minimum ventilating air quantities for diesel powered equipment, maintenance requirements, fire suppression, and design features for nonpermissible machines.

States. As noted in the first section of this part, few underground coal mines now use diesel engines. Several states have had bans on the use of such equipment: Pennsylvania, West Virginia, and Ohio.

Recently, Pennsylvania has replaced its ban with a special law that permits the use of diesel-powered equipment in deep coal mines under certain circumstances. The Pennsylvania statute goes beyond MSHA's new regulation on the use of diesel-powered equipment in underground coal mines. Of particular interest is that it specifically addresses diesel particulate. The State did not set a limit on the exposure of miners to dpm, nor did it establish a limit on the concentration of dpm in deep coal mines. Rather, it approached the issue by imposing controls that will limit dpm emissions at the source.

First, all diesel engines used in underground deep coal mines in Pennsylvania must be MSHA-approved engines with an ''exhaust emissions control and conditioning system'' that meets certain tests. (Article II–A, Section 203–A, Exhaust Emission Controls). Among these are dpm emissions from each engine no greater than ''an average concentration of 0.12 mg/m^3 diluted by fifty percent of the MSHA approval plate ventilation for that diesel engine.'' In addition, any exhaust emissions control and conditioning system must include a ''Diesel Particulate Matter (DPM) filter capable of an average of ninety-five percent or greater reduction of dpm emissions.'' It also requires the use of an oxidation catalytic converter. Thus, the Pennsylvania statute requires the use of low-emitting engines, and then the use of aftertreatment devices that significantly reduce what particulates are emitted from these engines.

The Pennsylvania law also has a number of other requirements for the safe use of diesel-powered equipment in the particularly hazardous environments of underground coal mines. Many of these parallel the requirements in MSHA's rule. Like MSHA's requirements, they too can result in reducing miner exposure to diesel particulate—e.g., regular maintenance of diesel engines by qualified personnel and equipment operator examinations. The requirements in the Pennsylvania law take into account the need to maintain the aftertreatment devices required to control diesel particulate (see, e.g., Section 217–A (b)(6)).

West Virginia has also lifted its ban, subject to rules to be developed by a joint labor-management commission. MSHA understands that pursuant to the West Virginia law lifting the ban, the Commission has only a limited time to determine the applicable rules, or the matter is to be referred to an arbitrator for resolution.

Other Countries. Concerns about air pollution have been a major impetus for most countries' standards on vehicle emissions, including diesel particulate. Most industrialized nations recognize the fundamental principle that their citizens should be protected against recognized health risks from air pollution and that this requires the control of particulate such as diesel exhaust. In November of 1995, for example, the government of the United Kingdom recommended a limit on PM10, and noted it would be taking further actions to limit airborne particulate matter (including a special study of dust from surface minerals workings).

Concerns about international trade have been another impetus. Diesel engines are sold to an international market to power many types of industrial and nonindustrial machinery and equipment. The European Union manufacturers exported more than 50 percent of their products, mainly to South Korea, Taiwan, China, Australia, New Zealand and the United States. Germany and the United Kingdom, two major producers, have pushed for harmonized world standards to level the playing field among the various countries' engine producers and to simplify the acceptance of their products by other countries (Financial Times, 1996). This includes products that must be designed to meet pollution standards. The European Union (EU) is now considering a proposal to set an EU-wide standard for the control of the emission of pollutants from non-road mobile machinery (Official Journal of European Communities, 1995). The proposal would largely track that of the U.S. Environmental Protection Agency's final rule on the Control of Air Pollution Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or above 37 kilowatts (50 HP)p (discussed in Section 3 of this part of the preamble).

A third impetus to action has been the studies of the health effects of worker exposure to diesel exhaust—many of which have been epidemiological studies concerning workers in other countries. As noted in Part III of this preamble, the studies include cohorts of Swedish dock workers and bus garage workers, Canadian railway workers and miners, French workers, London transport workers, and Danish chimney sweeps.

Below, the agency summarizes some information obtained on exposure limits of other countries. Due to differences in regulatory schemes among nations considering the effects of diesel exhaust, countries which have addressed the issue are more likely to have issued recommendations rather than a mandatory maximum exposure limit. Some of these may have issued mandatory design features for diesel equipment to assist in achieving the recommended exposure level. Measurement systems also vary.

Germany. German legislation on dangerous substances classifies diesel engine emissions as carcinogenic. Therefore, diesel engines must be designed and operated using the latest technology to cut emissions. This always requires an examination to determine whether the respective operations and activities may be carried out using other types of less polluting equipment. If, as a result of the examination, it is decided that the use of diesel engines is necessary, measures must be instituted to reduce emissions. Such measures can include low-polluting diesel engines, low sulphur fuels, regular maintenance, and, where technology permits, the use of particulate traps. To reduce exposure levels further, diesel engine emissions may be regulated directly at the source; ventilation systems may be required to be installed.

The use of diesel vehicles in a fully or partly enclosed working space—such as in an underground mine—may be restricted by the government, depending on the necessary engine power or load capacity and on whether the relevant operation could be accomplished using a non-polluting vehicle, e.g. an electrically powered vehicle. When determining whether alternate equipment is to be used, the burden to the operator to use such equipment is also considered.

In April of 1997, the following permissible exposure limits (TRK[4]) for diesel engine emissions were instituted for workplaces in mining.

(1) non-coal underground mining and construction work: TRK = 0.3 mg/m^3 of colloid dust[5]
(2) other: TRK = 0.1 mg/m^3 of colloid dust
(3) The average concentration of diesel engine emissions within a period of 15 minutes should never be higher than four times the TRK value.

The TRK is ascertained by determining the fraction of elemental carbon in the colloid (fine) dust by coulometric analysis. Determining the fraction of elemental carbon always involves the determination of total organic carbon in the course of analysis. If the workplace analysis shows that the fraction of elemental carbon in total carbon (elemental carbon plus organic carbon) is lower than 50%, or is subject to major fluctuations, then the TRK limits total carbon in such workplaces to 0.15 mg/m^3.

Irrespective of the TRK levels, the following additional measures are considered necessary once the concentration reaches 0.1 mg/m^3 colloid dust:

(1) Informing employees concerned;
(2) Limited working hours for certain staff categories;
(3) Special working hours; and
(4) Medical checkups.

If concentrations continue to fail to meet the TRK level, the employer must:

(1) Provide appropriate, effective, hygienic breathing apparatus, and

(2) Ensure that workers are not kept at the workplace for longer than absolutely necessary and that health regulations are observed.

Workers must use the breathing apparatus if the TRK levels for diesel engine emissions at the work place are exceeded. Due to the interference of recognized analysis techniques in coal mining, it is currently impossible to ascertain exposure levels in the air in coal mines. As a consequence, the coal mining authorities require the use of special low-polluting engines in underground mining and impose special requirements on the supply of fresh air to the workplace.

European Standards. On April 21, 1997, the draft of a European directive that applied to emissions from non-road mobile machinery was prepared. The directive proposed technical measures that would result in a reduction in emissions from internal-combustion engines (gasoline and diesel) installed in non-road mobile machinery, and type-approval procedures that would provide uniformity among the member nations for the approval of these engines.

The directive proposed a two-stage process. Stage 1, proposed to begin December 31, 1997, was for three different engine categories:

—A: 130 kW <= P <= 560 kW,
—B: 75 kW <= P < 130 kW,
—C: 37 kW <= P < 75 kW.

Stage 2, proposed to begin December 31, 1999, consisted of four engine categories being phased-in over a four-year period:

—D: after December 31,1999 for engines of a power output of 18 kW <= P < 37 kW,
—E: after December 31, 2000 for engines of a power output of 130 kW <= P <= 560 kW,
—F: after December 31, 2001 for engines of a power output of 75 kW <= P < 130 kW,
—G: after December 31, 2002 for engines of a power output of 37 kW <= P <= 75 kW.

The emissions shown in the following table for carbon monoxide, hydrocarbons, oxides of nitrogen and particulates are to be met for the respective engine categories described for stage I.

Net power (P) (kW)	Carbon Monoxide (P) (g/kWh)	Hydrocarbons (HC) (g/kWh)	Oxides of Nitrogen (No_X) (g/kWh)	Particulates (PT) (g/kWh)
$130 \le P < 560$	5.0	1.3	9.2	0.54
$75 \le P < 130$	5.0	1.3	9.2	0.70
$37 \le P < 75$	6.5	1.3	9.2	0.85

The engine emission limits that have to be achieved for stage II are shown in the following table. The emissions limits shown are engine-out limits and are to be achieved before any aftertreatment device is used.

Net power (P) (kW)	Carbon Monoxide (P) (g/kWh)	Hydrocarbons (HC) (g/kWh)	Oxides of Nitrogen (No_X) (g/kWh)	Particulates (PT) (g/kWh)
$130 \le P < 560$	3.5	1.0	6.0	0.2
$75 \le P < 130$	5.0	1.0	6.0	0.3
$37 \le P < 75$	5.0	1.3	7.0	0.4
$18 \le P < 37$	5.5	1.5	8.0	0.8

[4] TRK is the technical exposure limit of a hazardous material that defines the concentration of gas, vapour or airborne particulates which is the minimum possible with current technology and which serves as a guide for necessary protective measures and monitoring in the workplace.

[5] Colloid dust is defined as that part of total respirable dust in a workplace that passes the alveolar ducts of the worker.

Canada (Related developments in Canada). The Mining and Minerals Research Laboratories (MMRL) of the Canada Centre for Mineral and Energy Technology (CANMET), an arm of the Federal Department of Natural Resources Canada (NRCAN), began work in the early 1970s to develop measurement tools and control technologies for diesel particulate matter (dpm). In 1978, I.W. French and Dr. Anne Mildon produced a CANMET-sponsored contract study entitled: ''Health Implications of Exposure of Underground Mine Workers to Diesel Exhaust Emissions.'' In this document, an Air Quality Index (AQI) was developed involving several major diesel contaminants (CO, NO, NO2, SO2 and RCD—respirable combustible dust which is mostly dpm). These concentrations were divided by their then current permissible exposure limits, and the sum of the several ratios indicates the level of pollution in the mine atmosphere. The maximum value for this Index was fixed at 3.0. This criterion was determined by the known health hazard associated with small particle inhalation, and the known chemical composition of dpm, among other matters.

Subsequently, in 1986, the Canadian Ad hoc Diesel Committee was formed from all segments of the mining industry, including: mine operators, the labor force, equipment manufacturers, research agencies including CANMET, and Canadian regulatory bodies. The objective was the identification of major problems for research and development attention, the undertaking of the indicated studies, and the application of the results to reduce the impact of diesel machines on the health of underground miners.

In 1990–91, CANMET developed an RCD mine sampling protocol on behalf of the Ad hoc Committee. Then current underground sampling studies indicated an average ratio of RCD to dpm of 1.5. This factor accounted for the presence of other airborne combustible liquids including fuel, lubrication and particularly drilling oils, in addition to the dpm.

The original 1978 French-Mildon study was updated under a CANMET contract in 1990. It recommended that the dpm levels be reduced to 0.5 mg/m^3 (suggesting a corresponding RCD level of 0.75 mg/m^3).

However, in 1991, the AD HOC Committee decided to set an interim recommended RCD level of 1.5 mg/m^3 (the equivalent 1.0 mg/m^3). This value matched the then recommended, but not promulgated, MSHA 'Ventilation Index' value for dpm of 1.0 mg/m^3. Consequently, all of the North American mining industry then seemed to be accepting the same maximum levels of dpm.

It should be noted that for coal mine environments or other environments where a non-diesel carbonaceous aerosol is present, RCD analysis is not an appropriate measure of dpm levels.

Neither CANMET nor the Ad hoc Committee is a regulatory body. In Canada, mining is regulated by the individual provinces and territories. However, the federal laboratories provide: research and development facilities, advice based on research and development, and engine/machine certification services, in order to assist the provinces in their diesel-related mining regulatory functions.

Prior to the 1991 recommendation of the Ad hoc Committee, Quebec enacted regulations requiring: ventilation, a maximum of 0.25% sulfur content in diesel fuel; a prohibition on black smoke; exhaust cooling to a maximum temperature of 85°C; and the setting of maximum contaminant levels. Since 1997, new regulations add the CSA Standard for engine certification, a maximum RCD level of 1.5 mg/m^3, and the application of an exhaust treatment system.

Further, after the Ad hoc Committee recommendation was published in 1991 (RCDmax = 1.5 mg/m^3), various provinces took the following actions:

(1) Five provinces—British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia, and the Northwest Territories, adopted an RCD limit of 1.5 mg/m^3.

(2) Two others, Manitoba and Newfoundland/Labrador, have been adopting the ACGIH TLVs.

(3) Two provinces, Alberta and Saskatchewan, and the Yukon Territory, continue to have no dpm limit.

Most Canadian Inspectorates accept the CSA Standard for diesel machine/engine certification. This Standard specifies the undiluted Exhaust Quality Index (EQI) criterion for calculation of the ventilation in cfm, required for each diesel engine/machine. Fuel sulfur content, type of aftertreatment device and rated engine load factor are on-site, variable factors which may alter the ventilation ultimately required. Diesel fuel may not exceed 0.50% sulfur, and must have a minimum flash point of 52°C. However, most mines in Canada now use fuel containing less than 0.05% sulfur by weight.

In addition to limiting the RCD concentration, Ontario, established rules in 1994 that required diesel equipment to meet the Canadian Standards Association ''Non-Rail-Bound Diesel-Powered Machines for use in Non-Gassy Underground Mines'' (CSA M424.2–M90) Standard, excepting the ventilation assessment clauses. As far as fuel sulfur and flashpoint are concerned, Ontario is intending to change to: Smax = 0.05% from 0.25%, and maximum fuel flash point = 38°C from 52°C.

New Brunswick, in addition to limiting the RCD concentration, requires mine operators to submit an ambient air quality monitoring plan. Diesel engines above 100 horsepower must be certified, and there is a minimum ventilation requirement of 105 cfm/bhp.

Since 1996, the Ad hoc organization and the industry consortium called the Diesel Emissions Evaluation Program (DEEP) have been cooperating in a research and development program designed to reduce dpm levels in mines.

World Health Organization (WHO). Environmental Health Criteria 171 on ''Diesel Fuel and Exhaust Emissions'' is a 1996 monograph published under joint sponsorship of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. The monograph provides a comprehensive review of the literature and evaluates the risks for human health and the environment from exposure to diesel fuel and exhaust emissions.

The following tables compiled in the monograph show diesel engine exhaust limits for various exhaust components and illustrate that there is international concern about the amount of diesel exhaust being released into the environment.

TABLE II–3.—INTERNATIONAL LIMIT VALUES FOR COMPONENTS OF DIESEL EXHAUST LIGHTDUTY VEHICLES (G/KM)

Region	Carbon monoxide	Nitrogen oxides	Hydrocarbons	Particulates	Comments
Austria	2.1	0.62	0.25	0.124	≤3.5t; since 1991; from 1995, adoption of European Union standards planned.

TABLE II–3.—INTERNATIONAL LIMIT VALUES FOR COMPONENTS OF DIESEL EXHAUST LIGHTDUTY VEHICLES (G/KM)—Continued

Region	Carbon monoxide	Nitrogen oxides	Hydrocarbons	Particulates	Comments
Canada	2.1	0.62	0.25	0.12	Since 1987.
European Union	2.72	0.97 (with hydrocarbons).		0.14	Since 1992.
	1.0	0.7		0.08	From 1996.
Finland					Since 1993.
Japan	2.1	0.7	0.62	None	Since 1986.
	2.1	0.5	0.4	0.2	Since 1994.
Sweden, Norway	2.1	0.62 (city)	0.25	0.124	≤3.5t; from motor year 1992.
		0.76 (highway)			
Switzerland	2.1	0.62 (city)	0.25	0.124	≤3.5t; since 1988; from 1995, adoption of European Union standard planned.
USA (California)	2.1–5.2	0.2–0.6	0.2–0.3 (except methane).	0.05 (up to 31 000 km).	Depending on mileage.
US Environmental Protection Agency.	2.1–2.6	0.6–0.8	0.2	0.05–0.12	Depending on mileage.

TABLE II–4.—INTERNATIONAL LIMIT VALUES FOR COMPONENTS OF DIESEL EXHAUST HEAVY-DUTY VEHICLES (G/KWH)

Region	Carbon monoxide	Nitrogen oxides	Hydro-carbons	Particulates	Comments
Austria	4.9	9.0	1.23	0.4	
Canada	15.5	5.0	1.3	0.25	g/bhp-h.
	15.5	5.0	1.3	0.1	g/bhp-h; from 1995–97.
European Union	4.5	8.0	1.1	0.36	Since 1992.
	4.0	7.0	1.1	0.15	From 1995–96.
Japan	7.4	5.0	2.9	0.7	Indirect injection engines.
	7.4	6.0	2.9	0.7	Direct injection engines.
Sweden	4.9	9.0	1.23	0.4	
USA	15.5	5.0	1.3	0.07	g/bhp-h; bus.
	15.5	4.0	1.3	0.1	g/bhp-h; truck.
	15.5	5.0	1.3	0.05	g/bhp-h; bus; from 1998
	15.5	4.0	1.3	0.1	g/bhp-h; truck; from 1998.

Adapted from Mercedes-Benz AG (1994b).

With respect to the protection of human health, the monograph states that the data reviewed supports the conclusion that inhalation of diesel exhaust is of concern with respect to both neoplastic and non-neoplastic diseases. The monograph found that diesel exhaust ''is probably carcinogenic to humans.'' It also states that the particulate phase appears to have the greatest effect on health, and both the particle core and the associated organic materials have biological activity, although the gas-phase components cannot be disregarded. The monograph recommends the following actions for the protection of human health:

(1) Diesel exhaust emissions should be controlled as part of the overall control of atmospheric pollution, particularly in urban environments.

(2) Emissions should be controlled strictly by regulatory inspections and prompt remedial actions.

(3) Urgent efforts should be made to reduce emissions, specifically of particulates, by changing exhaust train techniques, engine design, and fuel consumption.

(4) In the occupational environment, good work practices should be encouraged, and adequate ventilation must be provided to prevent excessive exposure.

The monograph made no recommendations as to what constitutes excessive exposure.

International Agency for Research on Cancer (IARC)

The carcinogenic risks for human beings were evaluated by a working group convened by the International Agency for Research on Cancer in 1988 (International Agency for Research on Cancer, 1989b). The conclusions were:

(1) There is sufficient evidence for the carcinogenicity in experimental animals of the whole diesel engine exhaust.

(2) There is inadequate evidence for the carcinogenicity in animals of gas-phase diesel engine exhaust (with particles removed).

(3) There is sufficient evidence for the carcinogenicity in experimental animals of extracts of diesel engine exhaust particles.

(4) There is limited evidence for the carcinogenicity in humans of engine exhausts (unspecified as from diesel or gasoline engines).

Overall IARC Evaluation

Diesel engine exhaust is probably carcinogenic to humans (Group 2A).

(9) *MSHA's Initiative To Limit Miner Exposure to Diesel Particulate—a Brief History of This Rulemaking and Related Actions*

As discussed in part III of this preamble, by the early 1980's, the evidence indicating that exposure to diesel exhaust might be harmful to miners, particularly in underground mines, had started to grow. As a result, formal agency actions were initiated to investigate this possibility and to determine what, if any, actions might be appropriate. These actions are summarized here in chronological sequence, without comment as to the basis of any action or conclusion.

In 1984, in accordance with the § 102(b) of the Mine Act, NIOSH established a standing Mine Health Research Advisory Committee to advise it on matters involving or related to mine health research. In turn, that group established a subgroup to determine if:

> * * * there is a scientific basis for developing a recommendation on the use of diesel equipment in underground mining operations and defining the limits of current knowledge, and recommending areas of research for NIOSH, if any, taking into account other investigators' ongoing and planned research. (49 FR 37174).

In 1985, MSHA established an Interagency Task Group with the National Institute for Occupational Safety and Health (NIOSH) and the former Bureau of Mines (BOM) to assess the health and safety implications of the use of diesel-powered equipment in underground coal mines. In part, as a result of the recommendation of the Task Group, MSHA, in April 1986, began drafting proposed regulations on the approval and use of diesel-powered equipment in underground coal mines. Also in 1986, the subgroup of the NIOSH advisory committee studying this issue summarized the evidence available at that time as follows:

> It is our opinion that although there are some data suggesting a small excess risk of adverse health effects associated with exposure to diesel exhaust, these data are not compelling enough to exclude diesels from underground mines. In cases where diesel equipment is used in mines, controls should be employed to minimize exposure to diesel exhaust. (Interagency Task Group Report, 1986).

As noted previously in Section 7 of this part, in discussing MSHA's diesel equipment rule, on October 6, 1987, pursuant to Section 102(c) of the Mine Act, 30 U.S.C. 812(c), MSHA appointed an advisory committee ''to provide advice on the complex issues concerning the use of diesel-powered equipment in underground coal mines.'' (52 FR 37381). MSHA appointed nine members to the Advisory Committee. As required by Section 101(a)(1), MSHA provided the Advisory Committee with draft regulations on the approval and use of diesel-powered equipment in underground coal mines. The draft regulations did not include standards setting specific limitations on diesel particulate, nor had MSHA at that time determined that such standards should be promulgated.

In July 1988, the Advisory Committee completed its work with the issuance of a report entitled ''Report of the Mine Safety and Health Administration Advisory Committee on Standards and Regulations for Diesel-Powered Equipment in Underground Coal Mines.'' The Advisory Committee recommended that MSHA promulgate standards governing the approval and use of diesel-powered equipment in underground coal mines. The Advisory Committee recommended that MSHA promulgate standards limiting underground coal miners' exposure to diesel exhaust.

With respect to diesel particulate, the Advisory Committee recommended that MSHA ''set in motion a mechanism whereby a diesel particulate standard can be set.'' (MSHA, 1988). In this regard, the Advisory Committee determined that because of inadequacies in the data on the health effects of diesel particulate matter and inadequacies in the technology for monitoring the amount of diesel particulate matter at that time, it could not recommend that MSHA promulgate a standard specifically limiting the level of diesel particulate matter. (*Id*. 64–65). Instead, the Advisory Committee recommended that MSHA request NIOSH and the former BOM to prioritize research in the development of sampling methods and devices for diesel particulate. The Advisory Committee also recommended that MSHA request a study on the chronic and acute effects of diesel emissions (*Id*). In addition, the Advisory Committee recommended that the control of diesel particulate ''be accomplished through a combination of measures including fuel requirements, equipment design, and in-mine controls such as the ventilation system and equipment maintenance in conjunction with undiluted exhaust measurements.'' The Advisory Committee further recommended that particulate emissions ''be evaluated in the equipment approval process and a particulate emission index reported.'' (*Id*. at 9).

In addition, the Advisory Committee recommended that ''the total respirable particulate, including diesel particulate, should not exceed the existing two milligrams per cubic meter respirable dust standard.'' (*Id*. at 9). Section 202(b)(2) of the Mine Act requires that coal mine operators maintain the average concentration of respirable dust at their mines at or below two milligrams per cubic meter which effectively prohibits diesel particulate matter in excess of two milligrams per cubic meter, 30 U.S.C. 842(b)(2).

Also in 1988, NIOSH issued a Current Intelligence Bulletin recommending that whole diesel exhaust be regarded as a potential carcinogen and controlled to the lowest feasible exposure level (NIOSH, 1988). In its bulletin, NIOSH concluded that although the excess risk of cancer in diesel exhaust exposed workers has not been quantitatively estimated, it is logical to assume that reductions in exposure to diesel exhaust in the workplace would reduce the excess risk. NIOSH stated that ''[g]iven what we currently know there is an urgent need for efforts to be made to reduce occupational exposures to DEP [dpm] in mines.''

Consistent with the Advisory Committee's research recommendations, MSHA, in September 1988, formally requested NIOSH to perform a risk assessment for exposure to diesel particulate (57 FR 500). MSHA also requested assistance from NIOSH and the former BOM in developing sampling and analytical methodologies for assessing exposure to diesel particulate in mining operations. (*Id*.). In part, as a result of the Advisory Committee's recommendation, MSHA also participated in studies on diesel particulate sampling methodologies and determination of underground occupational exposure to diesel particulate. A list of the studies requested and reports thereof is set forth in 57 FR 500–501.

On October 4, 1989, MSHA published a Notice of Proposed Rulemaking on approval requirements, exposure monitoring, and safety requirements for the use of diesel-powered equipment in underground coal mines (54 FR 40950). The proposed rule, among other things, addressed, and in fact followed, the Advisory Committee's recommendation that MSHA promulgate regulations requiring the approval of diesel engines (54 FR 40951); limiting gaseous pollutants from diesel equipment, (*Id*.); establishing ventilation requirements based on approval plate dilution air quantities (54 FR 40990); requiring equipment maintenance (54 FR 40958); requiring that trained personnel work on diesel-powered equipment; (54 FR 40995), establishing fuel requirements, (*Id*.); establishing gaseous contaminant monitoring (54 FR 40989); and requiring that a particulate index indicating the quantity of air needed to dilute particulate emissions from diesel engines be established (54 FR 40953).

On January 6, 1992, MSHA published an Advance Notice of Proposed Rulemaking (ANPRM) indicating that it was in the early stages of developing a rule specifically addressing miners' exposure to diesel particulate (57 FR 500). In the ANPRM, MSHA, among other things, sought comment on specific reports on diesel particulate prepared by NIOSH and the former BOM. (*Id*.). MSHA also sought comment on reports on diesel particulate which were prepared by or in conjunction with MSHA (57 FR 501). The ANPRM also sought comments on the health effects, technological and economic feasibility, and provisions which should be considered for inclusion in a diesel particulate rule (57 FR 501). The notice also identified five specific areas where the agency was particularly interested in comments, and about which it asked a number of detailed questions: (1) exposure limits, including the basis therefore; (2) the validity of the NIOSH risk assessment model and the validity of various types of studies; (3) information about non-cancer risks, non-lung routes of entry, and the confounding effects of tobacco smoking; (4) the availability, accuracy and proper use of sampling and monitoring methods for diesel particulate; and (5) the technological and economic feasibility of various types of controls, including ventilation, diesel fuel, engine design, aftertreatment devices, and maintenance by mechanics with specialized training. The notice also solicited specific information from the mining community on ''the need for a medical surveillance or screening program and on the use of respiratory equipment.'' (57 FR 500). The comment period on the ANPRM closed on July 10, 1992.

While MSHA was completing a ''comprehensive analysis of the comments and any other information received'' in response to the ANPRM (57 FR 501), it took several actions to encourage the mining community to begin to deal with this problem, and to provide the knowledge and equipment needed for this task. As described earlier in this part, the Agency held several workshops in 1995, published a ''Toolbox'' of controls, and developed a spreadsheet template that allows mine operators to compare the impacts of various controls on dpm concentrations in individual mines.

On October 25, 1996, MSHA published a final rule addressing approval, exhaust monitoring, and safety requirements for the use of diesel-powered equipment in underground coal mines (61 FR 55412). The final rule addresses and in large part is consistent with the specific recommendations made by the Advisory Committee for limiting underground coal miners' exposure to diesel exhaust. (A further summary of this rule is contained in Section 7 of this part).

On February 26, 1997, the United Mine Workers of America petitioned the U.S. Court of Appeals for the D.C. Circuit to issue a writ of mandamus ordering the Secretary of Labor to promulgate a rule on diesel particulate. In Re: International Union, United Mine Workers of America , D.C. Cir. Ct. Appeals, No. 97–1109. The matter was scheduled for oral argument on September 12, 1997. On September 11, 1997, the Court granted the parties' joint motion to continue oral argument and hold the proceedings in abeyance. The Court directed the parties to file status reports or motions to govern future proceedings at 90-day intervals. On April 9, 1998, (63 FR 17492), MSHA published a proposed rule to limit the exposure of underground coal miners to dpm. On April 30, 1998, the Secretary filed a Motion To Dismiss based on the issuance of the notice of proposed rulemaking to limit the exposure of underground coal miners to dpm. On June 26, 1998, the Court dismissed the petition for Writ of Mandamus insofar as it sought regulations addressing diesel particulate.

III. Risk Assessment

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Introduction. MSHA has reviewed the scientific literature to evaluate the potential health effects of diesel particulate at occupational exposures encountered in the mining industry. Based on its review of the currently available information, this part of the preamble assesses the risks associated with those exposures. Additional material submitted for the record will be considered by MSHA before final determinations are made.

Agencies sometimes place risk assessments in the rulemaking record and provide only a summary in the preamble for a proposed rule. MSHA has decided that, in this case, it is important to disseminate a discussion of risk widely throughout the mining community. Therefore, the full assessment is being included as part of the preamble.

The risk assessment begins with a discussion of dpm exposure levels observed in the mining industry. This is followed by a review of information available to MSHA on health effects that have been associated with diesel particulate exposure. Finally, in the section entitled ''Characterization of Risk,'' the Agency considers three questions that must be addressed for rulemaking under the Mine Act, and relates the available information about risks of dpm exposure at current levels to the regulatory requirements.

A risk assessment must be technical enough to present the evidence and describe the main controversies surrounding it. At the same time, an overly technical presentation could cause stakeholders to lose sight of the main points. MSHA is guided by the first principle the National Research Council established for risk characterization: that the approach be—

> [a] decision driven activity, directed toward informing choices and solving problems*** Oversimplifying the science or skewing the results through selectivity can lead to the inappropriate use of scientific information in risk management decisions, but providing full information, if it does not address key concerns of the intended audience, can undermine that audience's trust in the risk analysis.

MSHA intends this risk assessment to further the rulemaking process. The purpose of a proposed rulemaking is to notify the regulated community of what information the agency is evaluating, how the agency believes it should evaluate that information, and what tentative conclusions the agency has drawn. Comments, supporting data, and guidance from all interested members of the public are encouraged. The risk assessment presented here is meant to facilitate public comment, thus helping to ensure that final rulemaking is based on as complete a record as possible—on both the evidence itself and the manner in which it is to be evaluated by the Agency. Those who want additional detail are welcome to examine the materials cited in this part, copies of which are included in MSHA's rulemaking record.

While this rulemaking covers only the underground metal and nonmetal sector, the risk assessment was prepared so as to enable MSHA to assess the risks throughout the mining industry. Accordingly, this information will be of interest to the entire mining community. With the exception of the discussion in Sec. III.3.c quantifying by how much the proposed rule may be expected to reduce current risks, this risk assessment is substantially the same as that published with MSHA's proposed rule to reduce dpm concentrations in underground coal mines (63 FR 17521).

MSHA had this risk assessment independently peer reviewed. The risk assessment presented here incorporates revisions made in accordance with the reviewers' recommendations. The reviewers stated that:

> * * * principles for identifying evidence and characterizing risk are thoughtfully set out. The scope of the document is carefully described, addressing potential concerns about the scope of coverage. Reference citations are adequate and up to date. The document is written in a balanced fashion, addressing uncertainties and asking for additional information and comments as appropriate. (Samet and Burke, Nov. 1997).

III.1. Exposures of U.S. Miners

Information about U.S. miner exposures comes from published studies and from additional mine inventories conducted by MSHA since 1993.[6] Previously published studies of U.S. miner exposure to dpm are: Watts (1989, 1992), Cantrell (1992, 1993), Haney (1992), and Tomb and Haney (1995). MSHA has also conducted inventories subsequent to the period covered in Tomb and Haney (1995), and the previously unpublished data are included here. The period covered on which this section is based, is late 1988 through mid 1997.

MSHA's field studies involved measuring dpm concentrations at a total of 48 mines: 25 underground metal and nonmetal (M/NM) mines, 12 underground coal mines, and 11 surface mining operations (both coal and M/NM). At all surface mines and all underground coal mines, dpm measurements were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor. With two exceptions, dpm measurements at underground M/NM mines were made using the RCD method (with no submicrometer impactor). Measurements at the two remaining underground M/NM mines were made using the size-selective method, as in coal and surface mines. The various methods of measuring dpm are explained in Part II of this preamble. Weighing errors inherent in the gravimetric analysis required for both size-selective and RCD methods become statistically insignificant at the relatively high dpm concentrations observed. Mines were selected from sites known to have diesel exposures. They do not constitute a random sample of mines, and care was taken in the text not to represent results as applying to the industry as a whole.

Each underground study typically included personal dpm exposure measurements for approximately five production workers. Also, area samples were collected in return airways of underground mines to determine diesel particulate emission rates. Operational information such as the amount and type of equipment, airflow rates, fuel, and maintenance was also recorded. In general, MSHA's studies focused on face production areas of mines, where the highest concentrations of dpm could be expected; but, since some miners do not spend their time in face areas, studies were performed in other areas as well, to get a more complete picture of miner exposure. Because of potential interferences from tobacco smoke in underground M/NM mines, samples were not collected on or near smokers.

Table III–1 summarizes key results from MSHA's studies. The higher concentrations in underground mines were typically found in the haulageways and face areas where numerous pieces of equipment were operating, or where insufficient air was available to ventilate the operation. In production areas and haulageways of underground mines where diesel powered equipment is used, the mean dpm concentration observed was 755 $\mu g/m^3$. By contrast, in travelways of underground mines where diesel powered equipment is used, the mean dpm concentration (based on 107 samples not included in Table III–1) was 307 $\mu g/m^3$. In surface mines, the higher concentrations were generally associated with truck drivers and front-end loader operators. The mean dpm concentration observed was less than 200 $\mu g/m^3$ at all 11 of the surface mines in which measurements were made. More information about the dpm concentrations observed in each sector is presented in the material that follows.

TABLE III–1.—FULL SHIFT DIESEL PARTICULATE MATTER CONCENTRATIONS OBSERVED IN PRODUCTION AREAS AND HAULAGEWAYS OF 48 DIESELIZED U.S. MINES. INTAKE AND RETURN AREA SAMPLES ARE EXCLUDED.

Mine type	Number of samples	Mean exposure $\mu g/m^3$	Exposure range $\mu g/m^3$
Surface	45	88	9–380
Underground Coal	226	644	0–3,650
Underground Metal and Nonmetal	331	830	10–5,570

[6] MSHA has only limited information about miner exposures in other countries. Based on 223 personal and area samples, average exposures at 21 Canadian noncoal mines were reported to range from 170 to 1300 $\mu g/m^3$ (respirable combustible dust), with maximum measurements ranging from 1020 to 3100 $\mu g/m^3$ (Gangel and Dainty, 1993). Among 622 full shift measurements collected since 1989 in German underground noncoal mines, 91 (15%) exceeded 400 $\mu g/m^3$ (total carbon) (Dahmann et al., 1996). As explained in Part II of this preamble, 400 $\mu g/m^3$ (total carbon) corresponds to approximately 500 $\mu g/m^3$ dpm.

III.1.a. Underground Coal Mines

Approximately 170 out of the 971 existing underground coal mines currently utilize diesel powered equipment. Of these 170 mines, fewer than 20 currently use diesel equipment for face coal haulage. The remaining mines use diesel equipment for transportation, materials handling and other support operations. MSHA focused its efforts in measuring dpm concentrations in coal mines on mines that use diesel powered equipment for face coal haulage. Twelve mines using diesel-powered face haulage were sampled. Mines with diesel powered face haulage were selected because the face is an area with a high concentration of vehicles operating at a heavy duty cycle at the furthest end of the mine's ventilation system.

Diesel particulate levels in underground mines depend on: (1) the amount, size, and workload of diesel equipment; (2) the rate of ventilation; and, (3) the effectiveness of whatever diesel particulate control technology may be in place. In the dieselized mines studied by MSHA, the sections used either two or three diesel coal haulage vehicles. In eastern mines the haulage vehicles were equipped with a nominal 100 horsepower engine. In western mines the haulage vehicles were equipped with a nominal 150 horsepower engine. Ventilation rates ranged from the nameplate requirement, based on the 100–75–50 percent rule (Holtz, 1960), to ten times the nameplate requirement. In most cases, the section airflow was approximately twice the name plate requirement. Control technology involved aftertreatment filters and fuel. Two types of aftertreatment filters were used. These filters included a disposable diesel emission filter (DDEF) and a Wire Mesh Filter (WMF). The DDEF is a commercially available product; the WMF was developed by and only used at one mine. Both low sulfur and high sulfur fuels were used.

Figure III–1 displays the range of exposure measurements obtained by MSHA in the field studies it conducted in underground coal mines. A study normally consisted of collecting samples on the continuous miner operator and ramcar operators for two to three shifts, along with area samples in the haulageways. A total of 142 personal samples and 84 area samples were collected. No statistically significant difference was observed in mean dpm concentration between the personal and area samples.

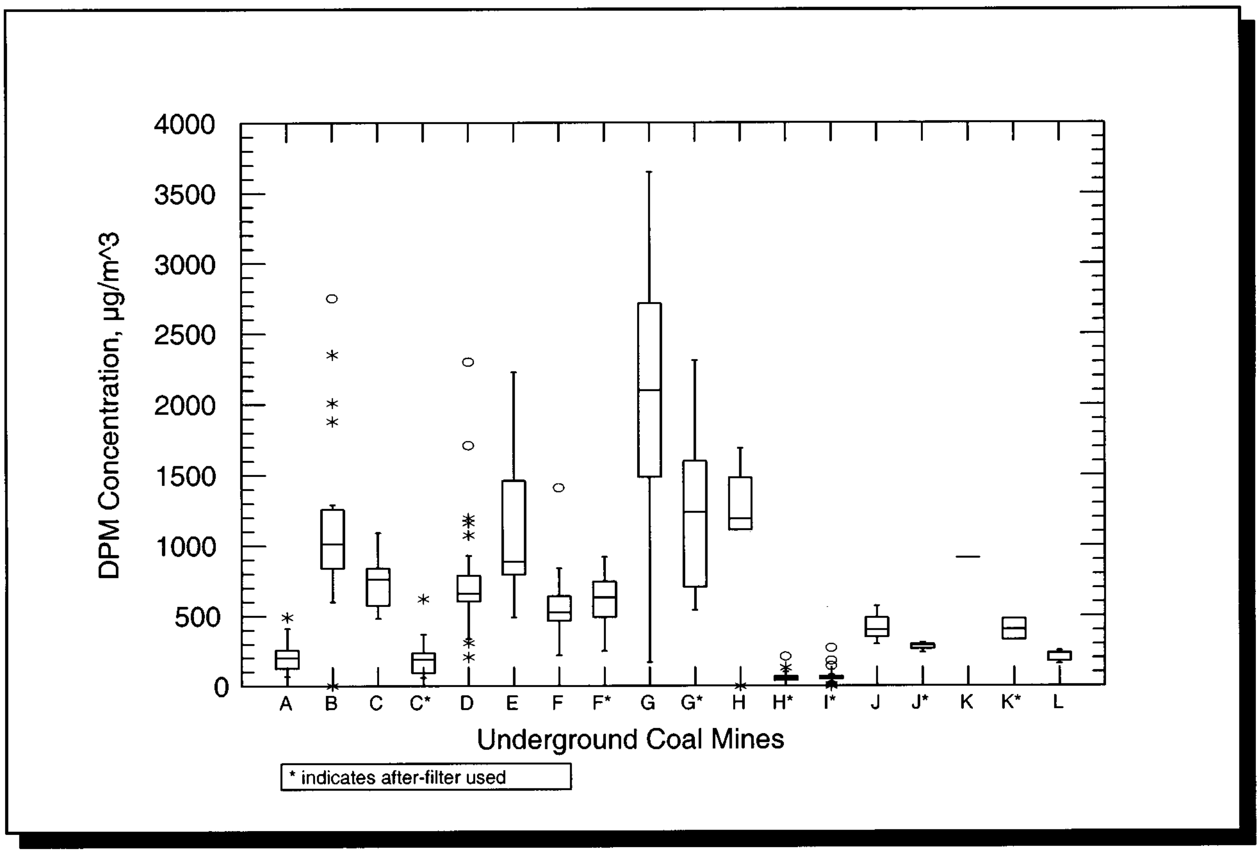

Figure III-1.-- Box plots (Tukey, 1977) for dpm concentrations observed at 12 underground coal mines. Top and bottom of each box represent upper and lower quartiles, respectively. "Belt" inside box represents median. Vertical lines span nearly all measurements. Isolated points are outliers, representing unusually high or low measurements compared to other observations at the same mine. All DPM measurements were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor.

In six mines, measurements were taken both with and without employment of disposable after treatment filters, so that a total of eighteen studies, carried out in twelve mines, are displayed.

Without employment of after treatment filters, average observed dpm concentrations exceeded 500 μg/m^3 in eight of the twelve mines and exceeded 1000 μg/m^3 in four.[7]

The highest dpm concentrations observed at coal mines were collected at Mine ''G.'' Eight of these samples were collected during employment of DDEF's, and eight were collected while filters were not being employed. Without filters, the mean dpm concentration observed at Mine ''G'' was 2052 μg/m^3 (median = 2100 μg/m^3). With disposable filters, the mean dropped to 1241 μg/m^3 (median = 1235 μg/m^3).

Filters were employed in three of the four studies showing median dpm concentration at or below 200 μg/m^3. After adjusting for outby sources of dpm, exposures were found to be reduced by up to 95 percent in mines using the DDEF and by up to 50 percent in the mine using the WMF.

The higher dpm concentrations observed at the mine using the WMF are attributable partly to the lower section airflow. The only study without filters showing a median concentration at or below 200 μg/m^3 was conducted in a mine (Mine ''A'') which had section airflow approximately ten times the nameplate requirement. The section airflow at the mine using the WMF was approximately the nameplate requirement.

III.1.b. Underground Metal and Nonmetal Mines

Currently there are approximately 260 underground M/NM mines in the United States. Nearly all of these mines utilize diesel powered equipment, and twenty-five of those doing so were sampled by MSHA for dpm.[8] The M/NM studies typically included measurements of dpm exposure for dieselized production equipment operators (such as truck drivers, roof bolters, haulage vehicles) on two to three shifts. A number of area samples were also collected. None of the M/NM mines studied were using diesel particulate afterfilters.

Figure III–2 displays the range of dpm concentrations measured by MSHA in the twenty-five underground M/NM mines studied. A total of 254 personal samples and 77 area samples were collected. No statistically significant difference was observed in mean dpm concentration between the personal and area samples. Personal exposures observed ranged from less than 100 μg/m^3 to more than 3500 μg/m^3. With the exception of Mine ''V'', personal exposures were for face workers. Mine ''V'' did not use dieselized face equipment.

Average observed dpm concentrations exceeded 500 μg/m^3 in 17 of the 25 M/NM mines and exceeded 1000 μg/m^3 in 12.[9] The highest dpm concentrations observed at M/NM mines were collected at Mine ''E''. Based on 16 samples, the mean dpm concentration observed at Mine ''E'' was 2008 μg/m^3 (median = 1835 μg/m^3). Twenty-five percent of the dpm measurements at this mine exceeded 2400 μg/m^3. All four of these were based on personal samples.

[7] In coal mine E, the average as expressed by the mean exceeded 1000 μg/m^3, but the median did not.

[8] MSHA will provide copies of these studies upon request.

[9] At M/NM mines C, I, J, and P, the average as expressed by the mean exceeded 1000 μg/m^3 but the median did not. At M/NM mines H and S, the median exceeded 1000 μg/m^3 but the mean did not. At M/NM mine K, the mean exceeded 500 μg/m^3, but the median did not.

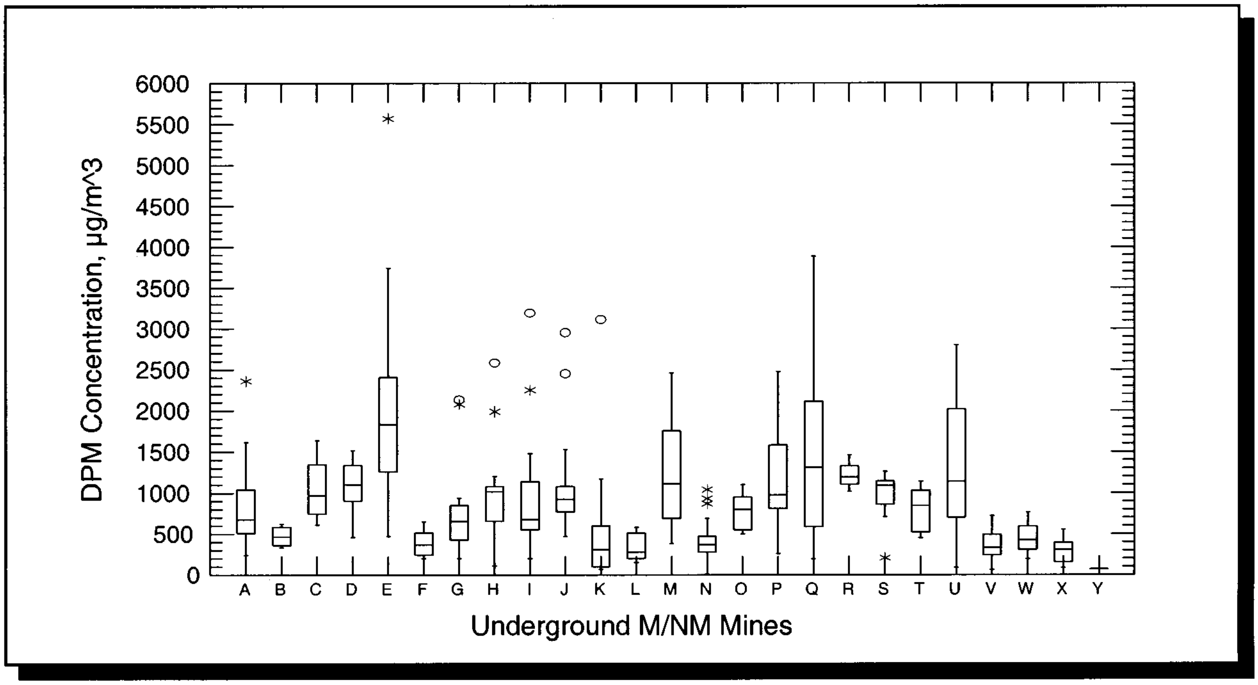

Figure III-2.-- Box plots (Tukey, 1977) for dpm concentrations observed at 25 underground metal and nonmetal mines. Top and bottom of each box represent upper and lower quartiles, respectively. "Belt" inside box represents median. Vertical lines span nearly all measurements. Isolated points are outliers, representing unusually high or low measurements compared to other observations at the same mine. Measurements at mines other than "D" and "T" were made using RCD method. Measurements at mines "D" and "T" were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor. Because of potential interferences from cigarette smoke, samples were not collected on or near smokers.

As with underground coal mines, dpm levels in underground M/NM mines are related to the amount and size of equipment, to the ventilation rate, and to the effectiveness of the diesel particulate control technology employed. In the dieselized M/NM mines studied by MSHA, front-end-loaders were used either to load ore onto trucks or to haul and load ore onto belts. Additional pieces of diesel powered support equipment, such as bolters and mantrips, were also used at the mines. The typical piece of production equipment was rated at 150 to 350 horsepower.

Ventilation rates in the M/NM mines studied mostly ranged from 100 to 200 cfm per horsepower of equipment. In only a few of the mines inventoried did ventilation exceed 200 cfm/hp. For single-level mines, working areas were ventilated in series, i.e., the exhaust air from one area became the intake for the next working area. For multi-level mines, each level typically had a separate fresh air supply. One or two working areas could be on a level. Control technology used to reduce diesel particulate emissions in mines inventoried included oxidation catalytic converters and engine maintenance programs. Both low sulfur and high sulfur fuel were used; some mines used aviation grade low sulfur fuel.

III.1.c. Surface Mines

Currently, there are approximately 12,200 surface mining operations in the United States. The total consists of approximately 1,700 coal mines and 10,500 M/NM mines. Virtually all of these mines utilize diesel powered equipment.

MSHA conducted diesel particulate studies at eleven surface mining operations: eight coal mines and three M/NM mines. To help select those surface facilities likely to have significant dpm concentrations, MSHA first made a visual examination (based on blackness of the filter) of surface mine respirable dust samples collected during a November 1994 study of surface coal mines. This preliminary screening of samples indicated that higher exposures to diesel particulate are typically associated with front-end-loader operators and haulage-truck operators; accordingly, sampling focused on these operations. A total of 45 samples were collected.

Figure III–3 displays the range of dpm concentrations measured at the eleven surface mines. The average dpm concentration observed was less than 200 $\mu g/m^3$ at all mines sampled. The maximum dpm concentration observed was less than or equal to 200 $\mu g/m^3$ in 8 of the 11 mines (73%). The surface mine studies indicate that even when sampling is performed at the areas of surface mines believed most likely to have high exposures, dpm concentrations are generally less than 200 $\mu g/m^3$.

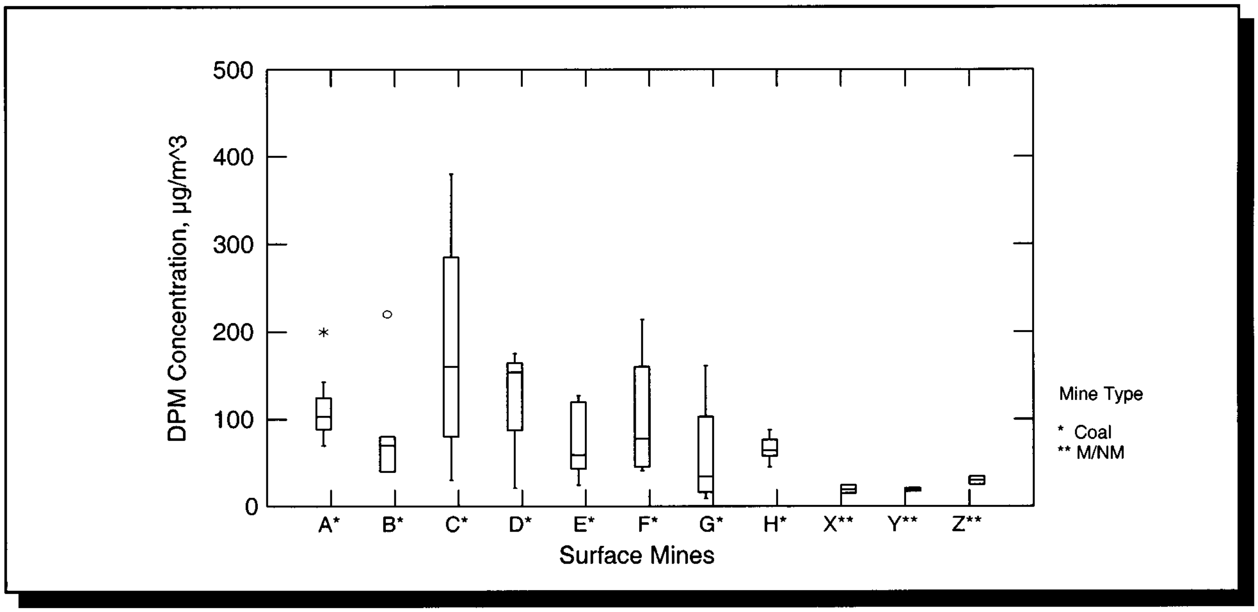

Figure III-3.--Box plots for dpm concentrations observed at 11 surface mines. Top and bottom of each box represent upper and lower quartiles, respectively. "Belt" inside box represents median. Vertical lines span nearly all measurements. Isolated points are outliers, representing unusually high or low measurements compared to other observations at the same mine (Tukey, 1977). All DPM measurements were made using the size-selective method, based on gravimetric determination of the amount of submicrometer dust collected with an impactor. Because of potential interferences from cigarette smoke, samples were not collected on smokers who worked inside enclosures.

III.1.d. Comparison of Miner Exposures to Exposures of Other Groups

Occupational exposure to diesel particulate primarily originates from industrial operations employing equipment powered with diesel engines. Diesel engines are used to power ships, locomotives, heavy duty trucks, heavy machinery, as well as a small number of light-duty passenger cars and trucks. NIOSH estimates that approximately 1.35 million workers are occupationally exposed to the combustion products of diesel fuel in approximately 80,000 workplaces in the United States. Workers who are likely to be exposed to diesel emissions include: mine workers; bridge and tunnel workers; railroad workers; loading dock workers; truck drivers; fork-lift drivers; farm workers; and, auto, truck, and bus maintenance garage workers (NIOSH, 1988). Besides miners, groups for which occupational exposures have been reported and health effects have been studied include dock workers, truck drivers, and railroad workers.

As estimated by the geometric mean, median occupational exposures reported for dock workers either operating or otherwise exposed to diesel fork lift trucks have ranged from 23 to 55 µg/m^3, as measured by submicrometer elemental carbon (NIOSH, 1990; Zaebst et al., 1991). Watts (1995) states that ''elemental carbon generally accounts for about 40% to 60% of diesel particulate mass.'' Assuming that, on average, the submicrometer elemental carbon constituted approximately 50% by mass of the whole diesel particulate, this would correspond to a range of 46 to 110 µg/m^3 in median dpm concentrations at various docks.

In a study of dpm exposures in the trucking industry, Zaebst et al. (1991) reported geometric mean concentrations of submicrometer carbon ranging from 2 to 7 µg/m^3 for drivers to 5 to 28 µg/m^3 for mechanics, depending on weather conditions. Again assuming that, on average, the mass concentration of whole diesel particulate is about twice that of submicrometer elemental carbon, the corresponding range of median dpm concentrations would be 4 to 56 µg/m^3.

Exposures of railroad workers to dpm were estimated by Woskie et al. (1988) and Schenker et al. (1990). As measured by total respirable particulate matter other than cigarette smoke, Woskie et al. reported geometric mean concentrations for various occupational categories of exposed railroad workers ranging from 49 to 191 µg/m^3.

Figure III–4 shows the range of median dpm concentrations observed for mine workers at different mines compared to the range of median concentrations estimated for dock workers (including forklift drivers at loading docks), truck drivers and mechanics, railroad workers, and urban ambient air.[10] The range for ambient air, 1 to 10 µg/m^3, was obtained from Cass and Gray (1995). For dock workers, truck drivers, and railroad workers, the estimated range of median exposures is respectively 46 to 110 µg/m^3, 4 to 56 µg/m^3, and 49 to 191 µg/m^3. The range of medians observed at different underground coal mines is 55 to 2100 µg/m^3, with filters employed at mines showing the lower concentrations. For underground M/NM mines, the corresponding range is 68 to 1835

[10] In the studies reviewed, investigators have used various statistical parameters, such as mean, median, or geometric mean, to summarize the dpm concentrations observed. Since the raw data are not available, MSHA was not able to summarize the data in exactly the same way for each category depicted in Figure III–4.

μg/m³, and for surface mines it is 19 to 160 μg/m³.

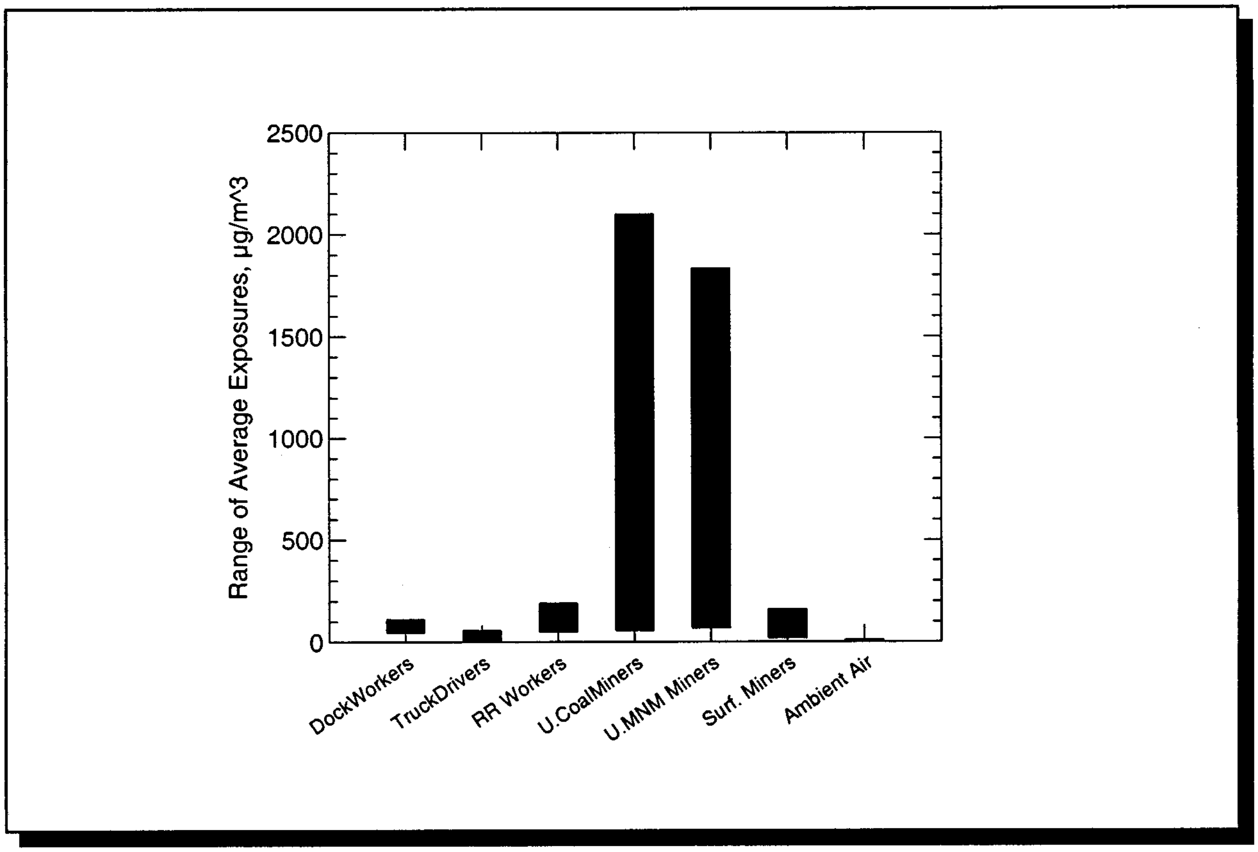

Figure III-4.--Range of average dpm exposures observed at various mines for underground and surface miners compared to range of average exposures reported for other occupations and for urban ambient air. Averages are represented by median observed within mines for mine workers, by median as estimated with geometric mean reported for other occupations, and, for ambient air in urban environments, by the monthly mean estimated for different months and locations in Southern California. The range estimated for urban ambient air is roughly 1 to 10 $\mu g/m^3$.

As shown in Figure III–4, some miners are exposed to far higher concentrations of dpm than are any other populations for higher concerntrations of dpm than are any other populations for which data have been collected. Indeed, median dpm concentrations observed in some underground mines are up to 200 times as high as average environmental exposures in the most heavily polluted urban areas, and up to 10 times as high as median exposures estimated for the most heavily exposed workers in other occupational groups.

III.2. Health Effects Associated With DPM Exposures

This section reviews all the various health effects (of which MSHA is aware) that may be associated with exposure to diesel particulate. The review is divided into three main sections: acute effects, such as diminished pulmonary function and eye irritation; chronic effects, such as lung cancer; and mechanisms of toxicity. Prior to that review, however, the relevance of certain types of information will be considered. This discussion will address the relevance of health effects observed in animals, health effects that are reversible, and health effects associated with fine particulate matter in the ambient air.

III.2.a. Relevancy Considerations

III.2.a.i. Relevance of Health Effects Observed in Animals

Since the lungs of different species may react differently to particle inhalation, it is necessary to treat the results of animal studies with some caution. Evidence from animal studies can nevertheless be valuable, and those respondents to MSHA's ANPRM who addressed this question urged consideration of all animal studies related to the health effects of diesel exhaust.

Unlike humans, laboratory animals are bred to be homogeneous and can be randomly selected for either non-exposure or exposure to varying levels of a potentially toxic agent. This permits setting up experimental and control groups of animals that do not differ biologically prior to exposure. The consequences of exposure can then be determined by comparing responses in the experimental and control groups. After a prescribed duration of deliberate exposure, laboratory animals can also be sacrificed, dissected, and examined. This can contribute to an understanding of mechanisms by which inhaled particles may exert their effects on health. For this reason, discussion of the animal evidence is placed in the section entitled ''Mechanisms of Toxicity'' below.

Animal evidence also can help isolate the cause of adverse health effects observed among humans exposed to a variety of potentially hazardous substances. If, for example, the epidemiological data are unable to distinguish between several possible causes of increased risk of disease in a certain population, then controlled animal studies may provide evidence useful in suggesting the most likely explanation—and provide that information years in advance of definitive evidence from human observations.

Furthermore, results from animal studies may also serve as a check on the credibility of observations from epidemiological studies of human populations. If a particular health effect is observed in animals under controlled laboratory conditions, this tends to corroborate observations of similar effects in humans.

Accordingly, MSHA believes that judicious use of evidence from animal studies is appropriate. The extent to which MSHA relies upon such evidence to draw specific conclusions will be discussed below in connection with those conclusions.

III.2.a.ii. Relevance of Health Effects That are Reversible

Some reported health effects associated with dpm are apparently reversible—i.e., if the worker is moved away from the source for a few days, the health problem goes away. A good example is eye irritation.

In response to the ANPRM, questions were raised as to whether so-called ''reversible'' effects can constitute a ''material'' impairment. For example, one commenter argued that ''it is totally inappropriate for the agency to set permissible exposure limits based on temporary, reversible sensory irritation'' because such effects cannot be a ''material'' impairment of health or functional capacity within the definition of the Mine Act (American Mining Congress, 87–0–21, Executive Summary, p. 1, and Appendix A).

MSHA does not agree with this categorical view. Although the legislative history of the Mine Act is silent concerning the meaning of the term ''material impairment of health or functional capacity,'' and the issue has not been litigated within the context of the Mine Act, the statutory language about risk in the Mine Act is similar to that under the OSH Act. A similar argument was dispositively resolved in favor of the Occupational Safety and Health Administration (OSHA) by the 11th Circuit Court of Appeals in *AFL–CIO* v. *OSHA,* 965 F.2d 962, 974 (1992) (popularly known as the ''PEL's'' decision).

In that case, OSHA proposed new limits on 428 diverse substances. It grouped these into 18 categories based upon the primary health effects of those substances: e.g., neuropathic effects, sensory irritation, and cancer. (54 FR 2402). Challenges to this rule included the assertion that a ''sensory irritation'' was not a ''material impairment of health or functional capacity'' which could be regulated under the OSH Act. Industry petitioners argued that since irritant effects are transient in nature, they did not constitute a ''material impairment.'' The Court of Appeals decisively rejected this argument.

The court noted OSHA's position that effects such as stinging, itching and burning of the eyes, tearing, wheezing, and other types of sensory irritation can cause severe discomfort and be seriously disabling in some cases. Moreover, there was evidence that workers exposed to these sensory irritants could be distracted as a result of their symptoms, thereby endangering other workers and increasing the risk of accidents. (Id. at 974). This evidence included information from NIOSH about the general consequences of sensory irritants on job performance, as well as testimony by commenters on the proposed rule supporting the view that such health effects should be regarded as material health impairments. While acknowledging that ''irritation'' covers a spectrum of effects, some of which can be trivial, OSHA had concluded that the health effects associated with exposure to these substances warranted action—to ensure timely medical treatment, reduce the risks from increased absorption, and avoid a decreased resistance to infection (Id at 975). Finding OSHA's evaluation adequate, the Court of Appeals rejected petitioners' argument and stated the following:

> We interpret this explanation as indicating that OSHA finds that although minor irritation may not be a material impairment, there is a level at which such irritation becomes so severe that employee health and job performance are seriously threatened, even though those effects may be transitory. We find this explanation adequate. OSHA is not required to state with scientific certainty or precision the exact point at which each type of sensory or physical irritation becomes a material impairment. Moreover, section 6(b)(5) of the Act charges OSHA with addressing all forms of ''material impairment of health or functional capacity,'' and not exclusively ''death or serious physical harm'' or ''grave danger'' from exposure to toxic substances. See 29 U.S.C. 654(a)(1), 655(c). [Id. at 974].

III.2.a.iii. Relevance of Health Effects Associated with Fine Particulate Matter in Ambient Air

There have been many studies in recent years designed to determine whether the mix of particulate matter in ambient air is harmful to health. The evidence linking particulates in air pollution to health problems has long been compelling enough to warrant direction from the Congress to limit the concentration of such particulates (see part II, section 5 of this preamble). In recent years, the evidence of harmful effects due to airborne particulates has increased, and, moreover, has suggested that ''fine'' particulates (i.e., particles less than 2.5 µm in diameter) are more strongly associated than ''coarse'' particulates (i.e., respirable particles greater than 2.5 µm in diameter) with the adverse health effects observed (EPA, 1996).

MSHA recognizes that there are two difficulties involved in utilizing the evidence from such studies in assessing risks to miners from occupational dpm exposures. First, although dpm is a fine particulate, ambient air also contains fine particulates other than dpm. Therefore, health effects associated with exposures to fine particulate matter in air pollution studies are not associated specifically with exposures to dpm or any other one kind of fine particulate matter. Second, observations of adverse health effects in segments of the general population do not necessarily apply to the population of miners. Since, due to age and selection factors, the health of miners differs from that of the public as a whole, it is possible that fine particles might not affect miners, as a group, to the same extent as the general population.

Nevertheless, there are compelling reasons to consider this body of evidence. Since dpm is a type of respirable particle, information about health effects associated with exposures to respirable particles in general, and especially to fine particulate matter, is certainly relevant, even if difficult to apply directly to dpm exposures. Adverse health effects in the general population have been observed at ambient atmospheric particulate concentrations well below those studied in occupational settings. Furthermore, there is extensive literature showing that occupational dust exposures contribute to Chronic Obstructive Pulmonary Diseases (COPD), thereby compromising the pulmonary reserve of